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Agriculture Development Fund

FINAL REPORT

CHEMICAL COMPOSITION AND VALUE-ADDED PROCESSING OF NATIVE SASKATCHEWAN FRUITS

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Adding value to agriculture...through research and development

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A) Project Title: Final Report for the Agriculture Development Fund Supported Project 95000134

B) Abstract

The overall objective of this research project is to establish a value-added program for fruits native to the Province of Saskatchewan. Possible value-added products and components of these fruits include: fruit juice concentrates; fruit purees; nutraceuticals; and food ingredients (e.g. natural colourants) from waste products of juice production (e.g. skins). The four minor objectives of this project which provide scientific data for our major objective include: (a) determination of the chemical composition of a selection of fruits native to Saskatchewan (dry ground cranberry, highbush cranberry; choke cherry; buffaloberry; sea-buckthorn; and blueberry); (b) examination of the processing ability of these fruits with respect to juice and puree production; (c) nutraceutical identification in these fruits or their waste products from juice production; (d) identification of possible food ingredients from the waste products of juice production. In addition, we would like to establish a laboratory/research group which could respond to the on-going needs of the fruit producers and processors in the Province.

C) Executive Summary

It was the purpose of this study to investigate and identify value-added products from a selection of fruits native to Saskatchewan. The six fruits chosen for this study were dry ground cranberry, highbush cranberry, choke cherry, buffaloberry, blueberry, and sea-buckthorn. Initially saskatoon berry was also identified as a possible raw material, however, we have not pursued this fruit due to possible overlaps in research with the ADF sponsored Native Fruit Development Program. In addition, blueberry studies were terminated in 1997 due to difficulties in obtaining sufficient raw product for juice production studies.

Our stated objectives of this three year study included: (a) determination of the chemical composition of a selection of fruits native to Saskatchewan (dry ground cranberry, highbush cranberry; choke cherry; buffaloberry; and sea-buckthorn); (b) examination of the processing ability of these fruits with respect to juice and puree production; (c) nutraceutical identification in these fruits or their waste products from juice production; (d) identification of possible food ingredients from the waste products of juice production. In addition, it is our goal to obtain long term funding in order to establish a laboratory/research group which then would respond to the on-going needs of the fruit producers and processors in the Province.

Our research to date has focused on the analysis of the aforementioned berries over a three year period (1996-98) with respect to their moisture, protein, ash, lipid, fibre, carbohydrate (glucose, fructose, sorbitol, and sucrose), pH, organic acid (malic, maleic, citric, quinic), starch, and mineral (calcium, magnesium, potassium, sodium) content. We believe that we have established the first extensive data base on each of the aforementioned fruits and this chemical information is a crucial part of the equation for subsequent commercial production of juice from these berries.

Chemical analysis data show that each of these berries contain high levels of fibre which is mainly due to the presence of non-cellulose polysaccharides. In addition, buffaloberry and choke cherry each show a high level of protein when compared to the other berries studied and those typically used in commercial fruit juices (apple, orange, grapefruit, etc.). We also confirmed our original (see Feb 1998 report) findings on the high level of hydrophobic (lipid content) compounds in sea-buckthorn. This could be a marketing problem for this berry and any value-added product produced from this berry unless the lipid content is related to polyphenolic compounds/nutraceuticals.

We report the analysis of a group of nutraceutical (chemicals which have specific health promoting properties) compounds (anthocyanins; phenolics) from each of the berries analyzed in this study (sea-buckthorn does not contain anthocyanins but does contain polyphenols).

Anthocyanins are a group of water soluble pigments that are widespread in the plant kingdom. Many fruits, vegetables, and flowers owe their attractive colouration to this group of compounds. Anthocyanins have received a great deal of attention recently for their nutraceutical properties. Anthocyanins and anthocyanidins (so named because of the absence of carbohydrate) have been identified for their possible role in tumour prevention, delay in aging/loss of memory and motor skills, and they have been shown to interact with low density lipoprotein (LDL) and reduce the risk of coronary heart disease. In addition, proanthocyanidins (the precursors to anthocyanins) have been shown to alleviate/prevent urinary tract infection.

Our analytical results indicate that the anthocyanin content of dried ground and highbush cranberry harvested from different regions of the Province showed significantly higher levels than those present in commercial cranberry samples (note: not cranberry cocktail which may contain from 1-25% cranberry juice). Our analytical results on these berries show levels in expressed juice from 300-900 ppm of cyanidin galactoside and 40-135 ppm of cyanidin arabinoside; while the levels for commercial cranberry juice were significantly lower. In addition, the cyanidin glucoside concentration for buffaloberry and choke cherry were equivalent to that found in commercial cranberry juice.

Phenolic compounds in fruits are of particular interest because of their roles in taste (bitterness, astringency), colour (browning), and appearance (haze, sediment). In addition, phenolics are considered to be phytochemicals because consumption of foods containing these compounds has been correlated with reduced coronary heart disease mortality. There are several classes of phenolic compounds found in food, which are broadly separated into two classes: the flavonoids and the nonflavonoids. Although a sub-class of flavonoids are anthocyanins, the phenolic compounds of interest in the five berries included in this study are commonly referred to as flavonols (e.g. catechin).

Our analytical results have clearly shown the presence of a variety of identified flavanols in highbush and dry ground cranberry. In addition, we have found appreciable levels of these identifiable compounds in sea-buckthorn, buffaloberry and choke cherry. We also noted

the presence of a variety of unidentified compounds in both the aqueous and methanol extracts of these berries which we believe are phenolics.

Methanol extracts of the five berries were used to conduct two *in vitro* antioxidant test. The first was used to determine their free radical scavenging properties employing the reagent 2,2-azinobis(3-ethylbenzothiazoline)-6-sulfonic acid (ABTS; Pellegrini, N. et al., 1999. Meth. Enzymol. 299:384-388); and the second evaluated the hydroxyl radical scavenging efficacy of the extracts via an ascorbic acid mediated Fenton reaction (Aruoma, O.I., J. AOCS. 1996. 73:1617-1625). Comparison of these results to methanolic apple and ginseng (*Panax quinquefolium L.*) extracts showed that the free radical and hydroxyl radical scavenging efficacy for each of these fruits was greater than apple but less than ginseng.

This research project also investigated the production of juices from the five berries previously mentioned using a variety of commercially available enzymes.

In general, juice production from raw fruit involves the following processing stages: (1) milling of the fruit to produce a pomace; (2) enzymatic treatment of the pomace (liquifaction) in order to breakdown cell wall polysaccharides; this treatment results in increased expression of juice from the fruit; (3) pressing of the enzymatically treated pomace; (4) filtration; (5) water removal from the filtered juice to produce a concentrate.

Fruit purees/pomace were produced for each of the aforementioned fruits native to Saskatchewan employing a Robot Coupe C120 extraction system. Six commercial enzymes at two dosage levels, and three temperatures (22, 35 and 55 °C) were then employed for liquifaction of subsamples of the fruit pomace. The relationship of fruit, enzyme, enzyme dosage and temperature was determined employing viscometric analysis.

Viscosity is one of the most important rheological properties of foods. Viscosity is a measurement value reflecting the internal flow friction of a substance. It is measured by determining the force (shear stress) required to move the particles of the material at a certain deformation velocity (shear rate). The ratio of the shear stress and shear rate represents the viscosity. The measuring unit of viscosity is the 'poise' (dyne sec/cm^2); in practice, a 1/100 poise is used, known as the centi-poise (cP); water at room temperature has a viscosity of 1 cP.

In fruit juice production, for practical purposes, viscosity measurements are related to the ability of the enzymes to liquefy the polysaccharide material present in fruits which results in improved juice expression and a higher level of total soluble solids in the expressed juice.

Our results show the following overall trends: (a) good liquifaction for all berries except sea-buckthorn was accomplished with Biopectinase CCM at 35 °C (dosage dependent); (b) good liquifaction was obtained for all berries with DP321 at 22 °C (dosage dependent); (c) good liquifaction for buffaloberry and choke cherry was obtained with Crystalzyme PMLX at 25 °C (dosage dependent); and (d) Crystalzyme XL100 worked well for buffaloberry, choke cherry and sea-buckthorn at 22 °C.

D) Technical Report

Samples harvested in 1998 were stored at -40°C until processed. Prior to skin and seed removal the whole berries were brought to a temperature of -1°C. Skins and seed were removed from the berries employing a Robot Coupe C120 extraction system (Jackson, MS) and the resulting pomace was kept at -20°C until analyzed. Specific methods employed for sample analysis are outlined below.

Degree Brix

Brix readings were performed on room temperature juice samples. A Canlab Atago Illuminator refractometer (Canlab, Edmonton, AB) was used for all measurements. Each measurement was performed in triplicate.

pH

Juice pH readings were performed at room temperature on a Fisher Accumet, Model 15 pH Meter (Fischer Scientific, Edmonton, AB). A three point calibration (pH = 2, 4, and 7) was used

Moisture/Water

Whole berries (2 - 3 g) were masticated using a mortar and pestle. The crushed product was quantitatively transferred into aluminum weigh boats. Samples were dried, overnight, in a forced air oven at 85°C. Selected samples were also vacuum dried for 6 hours at 70°C.

Ash (AOAC, 13th ed., method 940.26)

Whole berries (15 - 20 g) were masticated using a mortar and pestle. The crushed product was quantitatively transferred into porcelain crucibles (VWR Canlab Scientific, West Chester, PA) with lids. Samples were pre-ashed overnight in a forced air oven at 105°C. Crucibles were placed in a Fischer Isotemp Model 186 temperature controlled muffle furnance (Fischer Scientific, Edmonton, AB) for 6 hours at 550°C. Samples that had not undergone complete combustion were wetted and re-ashed overnight.

Protein (AOAC, 13th ed., method 47.021 modified)

Whole berries (5 g) were transferred into Buchi Kjeldahl digestion tubes (Brinkman Instruments, Mississauga, ON). Analysis for total N content, with a factor of 6.25, was used to determine protein values.

Crude Fat (AACC method 30 - 25 Feeds)

Whole berries (3 - 5 g) were transferred into cellulose extraction thimbles, and masticated with high purity silica. The samples were dried overnight in a forced air oven @105°C. Samples were extracted employing a Goldfish apparatus (Labconco, Kansas City, MO) with refluxing petroleum ether as the solvent for 5 hours.

Seeds in Fruits (AOAC, 13th ed., method 949.08 modified)

Whole berries (50 g) were placed in a blender. 500 mL of hot water was added, and the mixture was blended on MIX for 1 - 2 minutes. The seeds were separated from skin and pulp by passing through a coarse mesh screen. The seeds were dried (@105°C for 10-12 hours) and evaluated for percent mass (based on the whole berry) employing a Metler AE2000 analytical balance (Metler, Zurich, Switzerland).

Hunter Lab

The juiced product's brightness, colour, and whiteness was evaluated using a Hunter Lab Colour and Colour Difference Meter. Measurement conditions included difference, rectangular, and a 10° observation.

Total Dietary Fibre (AOAC, 15th ed., method 985.29 modified)

Whole berries (5 - 8 g) were masticated using a mortar and pestle, and quantitatively transferred into aluminum weigh boats. This was repeated 4 times for each sample. The samples were dried overnight in a forced air oven at 85°C. Dried samples were ground to a fine powder with a mortar and pestle. Special care was taken to ensure all seeds were crushed. Ground samples (1 g) were transferred into 400 mL extraction beakers and digested for fibre as per the AOAC method.

Glucose, Fructose, Sucrose, and Sorbitol

Carbohydrate analysis was performed using a Dionex Bio LC 4000 gradient liquid chromatography unit (Dionex; Sunnyvale, CA) equipped with pulsed amperometric detection (PAD). The working electrode, during operation, was maintained at the following potentials and durations: E_1=0.05 V (t_1=0.299); E_2=0.60 V (t_2=0.299); and E_3=-0.80 V (t_3=0.499). An output range of 30K nA was used. Isocratic separation was achieved using a Dionex CarboPac PA1 anion exchange column (4 x 250 mm) equipped with a Dionex CarboPac PA1 Guard column. The mobile phase was 80 mM NaOH (v/v) aqueous solution at a flow rate of 1 mL/min. Operant pressure was ~1200 psi, and a 50 µL sample loop was used. Analysis time was ~10 minutes.

Organic Acid Analysis

Organic acid analysis was performed using a Waters 625 LC gradient controlled system (Waters Chromatography; Milford, MA) coupled to a Waters 484 tunable UV-Vis absorbance detector @228 nm. A 5 µm C_{18} column (250 x 4.6 mm; Poly LC; Columbia, MD) connected in series with a 5 µm C_{18} column (150 x 4.6 mm; Poly LC; Columbia, MD) was used for separation. The column was operated at ambient temperature using a 0.5% KH_2PO_4 (v/v) aqueous solution as the mobile phase (adjusted to pH 2.5 with phosphoric acid). The flow rate was 0.5 mL/min with an operant pressure of ~1600 psi. A 20 µL sample loop was used. Isocratic analysis time was ~50 minutes.

Mineral Analysis (AOAC, 15th ed., methods 977.29 and 987.02 modified)

Samples were wet ashed in nitric acid, filtered, diluted with deionized water and analyzed by atomic absorption spectroscopy.

Results

A) Chemical Composition/Analysis

1) Analytical results for purees produced from buffaloberry, choke cherry, dry ground cranberry, highbush cranberry and sea-buckthorn harvested in 1996, 1997 and 1998 are shown in Table 1. Average proximate analysis results for the whole berries without seeds for 1998 are also presented in Table 1. Results of interest include: the high levels of fibre in each of the berries analyzed (mainly due to an abundance of polysaccharide material); the high level of protein in both buffaloberry and choke cherry compared to the other berries analyzed and those fruits normally produced into juice (apple, orange, etc.); the high lipid content of sea-buckthorn (which could be a marketing problem for this berry and any value-added product produced from this berry unless the lipid content is related to polyphenolic compounds/nutraceuticals).

Selected representative chromatograms and standard curves for carbohydrates, organic acids and anthocyanins are also included for information purposes (Appendix A).

B) Nutraceutical Analysis and Identification

1) We introduced a relatively rapid isocratic procedure for the analysis of anthocyanins in fruit. Anthocyanin analysis was performed using a Waters 625 LC gradient controlled system coupled to a Waters 484 tunable UV-Vis absorbance detector (set @530 nm). A 5 μm C_{18} column (250 x 4.6 mm; Poly LC; Columbia, MD) was used for separation. The column was operated at ambient temperature using a 1.5% phosphoric acid (v/v)/8.5% acetonitrile (v/v)/8.5% acetic acid (v/v) aqueous solution as the mobile phase. The flow rate was 0.5 mL/min with an operant pressure of ~1700 psi. A 20 μL sample loop was used. Isocratic analysis time was ~45 minutes.

Anthocyanins are a group of water soluble pigments that are widespread in the plant kingdom. Many fruits, vegetables, and flowers owe their attractive colouration to this group of compounds which exist in the cell sap. All anthocyanins are derivatives of the basic flavylium cation structure (Figure I). More than twenty anthocyanidins (so named because of the absence of carbohydrate) are known, but only six (Figure II), pelargonidin, cyanidin, dephinidin, peonidin, petunidin, and malvidin, are important in food.

Anthocyanins have received a great deal of attention recently for their 'nutraceutical' (chemicals which have specific health promoting properties) properties. Anthocyanins and anthocyanidins have been identified for their possible role in tumour prevention, delay in aging/loss of memory and motor skills, and they have been shown to interact with LDL and reduce the risk of coronary disease. In addition, proanthocyanidins (precursors to anthocyanins) have been shown to alleviate/prevent urinary tract infection.

Qualitative analysis on anthocyanins were based on the analysis of authentic fruit juices (standards) obtained from various fruit juice companies (Ocean Spray Cranberries Inc.; Americana; American Fruit Products). These included the fruit recognized by the USDA (United States Department of Agriculture) as the standard for fresh cranberries (*Vaccinium macrocarpon*) and the so called European cranberry (*Vaccinium oxycoccus*) which contain five anthocyanins (cyanidin galactoside/cyanidin arabinoside/peonidin galactoside/peonidin glucoside/ and peonidin arabinoside); red and concord grape which both contain delphinidin

glucoside/petunidin glucoside/peonidin glucoside and malvidin glucoside; and red raspberry which contains cyanidin sophoroside and cyanidin rutinoside.

Anthocyanin identification in fruits native to Saskatchewan were based on a comparison of peak retention times to the aforementioned fruit juice standards, and are reported in Tables 2 and 3. These results show that the major anthocyanin present in buffaloberry and choke cherry is cyanidin glucoside. In addition, the results show that the two cranberries native to Saskatchewan show anthocyanin patterns which are similar qualitatively to *Vaccinium macrocarpon* although the dry ground cranberry native to our Province is *Vaccinium vitis-idaea*, and the highbush cranberry is *Viburnum americanum*.

In addition to a qualitative analysis of anthocyanins in these native fruits; we used authentic cranberry (*Vaccinium macrocarpon*.) as a standard for the comparison of concentration of identified anthocyanins. This was accomplished by diluting all of the purees and the authentic cranberry juice to 6 °Brix; samples were then analyzed by our reverse phase high performance liquid chromatographic (RP-HPLC) method and the results of these analyses are reported in Tables 2 and 3. These results show that the anthocyanin content of dry ground cranberry and highbush cranberry based on cyanidin galactoside (the anthocyanin present in the highest concentration) was higher in these berries when compared to authentic cranberry. In addition, both native 'cranberries' showed higher levels of cyanidin glucoside than was present in the authentic cranberry. Whereas the cyanidin glucoside concentration for buffaloberry and authentic cranberry were shown to be approximately equivalent.

Quantitative analysis of anthocyanins was also performed employing the total anthocyanin method of (Hong, V. and Wrolstad, R.E. 1990. J. Agric. Food Chem. 38:708-715) where 25 g of sample (pomace or whole berries) was mixed with 50 mL of 0.01% HCl in methanol and the resulting slurry was blended. The blended sample was then covered with aluminum foil and stored at 4 °C overnight. The settled sample was then vacuum filtered, washed with acidified methanol and re-vacuum filtered. The resulting clear solution was then transferred to a 250 mL volumetric flask and brought to volume with acidified methanol. This solution was then appropriately diluted with each of two buffers (sodium acetate buffer @pH 4.5; potassium chloride/hydrogen chloride buffer @ pH 1.0). Analysis was performed on a Spectronic 1201 over a range of 450-700nm. Results were calculated employing the method of Hong and Wrolstadt based on both cyanidin galactoside and cyanidin glucoside. In addition, quantitative analysis of two of the anthocyanins (cyanidin galactoside and cyanidin glucoside) was accomplished employing RP-HPLC with standards

(Extrasynthese, France). The quantitative results from the RP-HPLC analysis are reported in Table 3 and agreed in general with those obtained employing the total anthocyanin method.

2) We introduced a relatively rapid isocratic procedure for the analysis of polyphenols in fruit. Polyphenol analysis was performed using a Waters 625 LC gradient controlled system coupled to a Waters 484 tunable UV-Vis absorbance detector (set @280 nm). A 5 μm C_{18} column (250 x 4.6 mm; Jupiter by Phenomenex; Torrance, CA) coupled to a cartridge system guard column (C_{18} 4.0 mm x 3.0 mm; Phenomenex) was used for separation. The column was operated at ambient temperature using 300 mL of a 0.05 M potassium phosphate buffer (pH = 3.0 [adjusted with 85% HPO]) and 700 mL of acetonitrile as the mobile phase. The flow rate was 1.0 mL/min with an operant pressure of ~1900 psi. A 20 μL sample loop was used. Isocratic analysis time was ~95 minutes. Standards (Sigma-Aldrich Canada Ltd.) analyzed using this procedure included: arbutin, chlorogenic acid, caffeic acid, catechin, epicatechin, eriodictyol, hesperidin, kaempferol, naringenin, narirutin, narringin, neohesperidin, phloridzin, phloretin, quercitin, rutin and tangeritin. Standard curves were made for each of these standards which ranged from ~1 ppm to 28 ppm with correlation coefficients which ranged from 0.979 to 1.000.

The term polyphenols as used in this report refer to the range of chemical compounds which are present in fruits that possess an aromatic ring bearing a hydroxyl substituent or substituents which are not generally responsible for food colour (i.e. pigments such as anthocyanins). Many classes of polyphenols have been identified in fruits and include: (a) hydroxycinnamic acid derivatives (such as p-coumaric acid; caffeic acid; ferulic acid); (b) catechinis (catechin; epicatechin); (c) dihydrochalcones (phloretin); (d) flavanones (naringenin); (e) flavones (apigenin, luteolin); and (f) flavonols (quercetin; kaempferol).

In our research we have found the presence of chlorogenic acid, catechin, epicatechin, and caffeic acid in both highbush and dry ground cranberry. The concentration of these polyphenols range from ~2-20 ppm in enzyme treated juice from the whole berry. These results compare favourably to those of apple juice which is currently being promoted for its role as a functional food (based on the presence of the antioxidant quercetin). In addition, we found the presence of catechin, epicatechin, and quercetin in buffaloberry and choke cherry; and catechin, epicatechin and kaempferol in sea-buckthorn berries. Aside from these identifiable (based on retention time comparisons to standards) polyphenols we also noted the presence of a variety of other hydrophobic compounds (which may be phenolics

based on the combination of detection wavelength, stationary and mobile phases used) which appeared in the chromatogram but which we could not match to the standards which we ran in conjunction with these samples.

The level of polyphenols in fruits have been show to vary considerably from species to species, cultivar to cultivar, season to season, and from differing geographical regions. In general, the concentration of polyphenols decreases as a fruit matures.

Highly hydroxylated phenolics have been shown to be very good antioxidants. A large number of diseases, disorders, and conditions have been shown to be significantly affected by the administration of antioxidants. These include but are not limited to: cancer and preneoplastic conditions; cataracts; cardiovascular disorders; arthritis; reperfusion injury; and nervous system disorders (J.A. Olson; Antioxidant in Health and Disease. In: Natural Protectants against Natural Toxicants. W.R. Bidlack and S.T. Omaye (eds). 1995).

In our work we employed two *in vitro* analytical tests to determine the antioxidant efficacy of the berries identified in this study. A complete description for each of these assays is as follows:

1) Free radical scavenging ability: ABTS radical was generated by the reaction between 2,2-azinobis(3-ethylbenzothiazoline)-6-sulfonic acid with potassium persulfate. Equal volumes (25-100 μL depending on the sample) of the methanolic fruit extract was mixed with ABTS solution in 1 mL of ethanol. Free radical scavenging ability was determined by comparison of sample and blank reading @734 nm;

2) Hydroxyl radical scavenging ability: Deoxyribose (4.0 mM), $FeCl_3$ (100 μM), L-ascorbic acid (100 μM), EDTA (100 μM) and methanolic fruit extract were mixed and then incubated for 30-90 minutes (dependent upon the fruit sample) @37°C. The reaction mixture was then mixed with an equal volume of 10% trichloroacetic acid and 0.5% 2-thobarbituric acid/0.02% BHT, followed by heating in boiling water for 15 minutes. The absorbance @532 nm was taken after cooling of the sample.

The results from the free radical scavenging ability employing ABTS indicated that at equal concentrations the % inhibition for all five berry methanol extracts was significantly

($p<0.05$) higher than that observed for apple (Red Delicious/Golden Delicious blend) but was significantly ($p<0.05$) lower than that observed for North American ginseng.

A common finding from the hydroxyl radical scavenging model was the fact that all methanolic berry extracts showed antioxidant activity. By comparing the lag phase of lipid peroxidation, the highest antioxidant activity amongst the berry extracts was noted for sea-buckthorn with the other four berries being indistinguishable from a statistical point of view. It is interesting to note that each of the five berries showed a lag phase inhibition greater than that observed for apple (Red Delicious/Golden Delicious blend) but significantly ($p<0.05$) lower than that observed for North American ginseng.

C) Juice Extraction via Enzymatic Treatment

1) Samples harvested in 1998 were stored at -40°C until processed. Prior to skin and seed removal the whole berries were brought to a temperature of -1°C. Skins and seed were removed from the berries employing a Robot Coupe C120 extraction system (Jackson, MS) and the resulting pomace was kept at -20°C until analyzed.

The six commercial enzymes used in this study, and their temperature and pH activity ranges are reported in Table 4. The enzymes included: Crystalzyme PMLX which is a pectinase enzyme; Crystalzyme XL100 which is also a pectinase enzyme but which is used mainly in vegetable liquifaction; DP321, a developmental enzymatic preparation (used with permission of Valley Research Inc.) which is an enzyme cocktail containing pectinase, cellulase, and hemicellulase activities. All of these enzymes were provided by Valley Research Inc., Southbend, Indiana (USA). Biopectinase CCM is a pectinase which also shows pectin transeliminase activity; Biopectinase HM/P, an enzyme cocktail containing pectinase, cellulase and hemicellulase activities; and Biopectinase 300, an enzyme cocktail containing pectinase, cellulase and proteinase activities. All of these enzymes were provided by Quest International, Cork, Ireland. The experimental protocol followed for all liquifaction studies was:

a) fruit purees were brought to refrigeration (4°C) and then room temperature over a three day period;

b) approximately 125 g of puree was transferred to a 250 mL erlenmeyer flask and the flasks were then placed in a shaking water bath set at the appropriate reaction

temperature (22°C; 35°C; 55°C);

c) two levels (dosage) of enzyme addition were used, which were dependent upon the enzyme: (1) crystalzyme PMLX; 25 mL/100 kg (low) and 100 mL/1000 g (high); (2) crystalzyme 100XL; 80 mL/3780 L (low) and 160 mL/3780 L (high); (3) DP321; 0.08%/wt to wt basis (low) and 0.4%/wt to wt basis (high); (4) biopectinase CCM; 2 g/1000 L (low) and 10 g/1000 L (high); (5) biopectinase HM/P; 2 g/1000 L (low) and 10 g/1000 L (high); (6) biopectinase 300; 14.8 mL/1000 kg (low, at temperatures <26°C) or 9.85 mL/1000 kg (low, at temperatures between 54-60°C) and 29.6 mL/1000 kg (high, at temperatures <26°C) and 22.2 mL/1000 kg (high, at temperatures between 54-60°C);

d) flask containing puree + enzyme were loosely covered with parafilm and shaken and manually stirred (every 30 minutes) for a 10-12 hour reaction period;

e) samples were then transferred to a stator and viscosity measurements were determined at a temperature of 25°C using a Haake Rotational Viscometer;

The preliminary (note: only final torque at the two dosage levels is reported) results from the viscometric experiments of the five berry samples run at two dosage levels and three temperatures (total of 90 experiments) are shown in Table 5; the torque for each fruit puree before enzyme addition is also reported in Table 5.

Viscosity results (based on torque only) show the following:

a) buffaloberry: a significant decrease (from 25.2 to 9.8) in viscosity was observed using Crystalzyme PMLX at 22°C; significant viscosity increases were observed for all enzymes at 55°C (appears to be due to 'gel' formation);

b) choke cherry: a significant decrease in viscosity was observed for all enzymes at 22°C with the optimal being DP321 (from 51.5 to 18.6); a decrease in viscosity was also observed for each enzyme at each temperature;

c) dried ground cranberry: the viscosity of this puree was low (based on a torque reading of 10.0) to begin with and was significantly reduced with Crystalzyme PMLX, Biopectinase 300 and DP321, all at a temperature of 22°C;

d) highbush cranberry: a significant decrease (from 16.2 to 12.0-12.5) was observed at 22°C using either Biopectinase 300 or Crystalzyme 100XL; and the same viscosity decrease was observed employing Biopectinase HM/P at 35°C;

e) sea-buckthorn: this pomace had the lowest (based on a torque of 4.0) viscosity of all those tested. This low viscosity would make this an ideal berry for juice production (note: obviously, total soluble solids, flavour, colour stability, raw material cost and availability, etc. would be more important parameters for juice production). Significant reduction in viscosity was noted for Crystalzyme PMLX (55°C), Crystalzyme 100XL (22°C), Biopectinase CCM (35 and 55°C), Biopectinase HM/P (35 and 55°C), Biopectinase 300 (22 and 55°C), and DP321 (22 and 35°C).

D) Juice Production from Buffaloberry, Chokecherries and Dry Ground Cranberry

Scale-up experiments were conducted on buffaloberry, choke cherry and dry ground cranberry with respect to juice yield and total mass balance.

1) Buffaloberry: The starting weight of berries was 8.87 kg. These previously frozen (@-40°C) were brought to a temperature of -1°C and then skin and seed were removed from the berries employing a Robot Coupe C120 extraction system (Jackson, MS). The mass of pomace was 7.69 kg and the mass of seeds/skins was 0.55 kg; for a total mass recovery of 93.0%. The pomace was then treated with a mixture of Crystalzyme PMLX (425 μL) and Crystalzyme 100XL (125 μL) @22°C for 12 hours. Following enzymatic liquifaction the resulting solution was filtered through diatomaceous earth. The weight of the resulting clear liquid was 6.54 kg for a total yield of 74% from the original fruit;

2) Choke cherry: The starting weight of berries was 9.81 kg. These previously frozen (@-40°C) were brought to a temperature of -1°C and then skin and seed were removed from the berries employing a Robot Coupe C120 extraction system (Jackson, MS). The mass of pomace was 6.73 kg and the mass of seeds/skins was 3.01 kg; for a total mass recovery of 99.3%. The pomace was then treated with a mixture of DP321 (137 μL) and Crystalzyme 100XL (137 μL) @22°C for 12 hours. Following enzymatic liquifaction the resulting solution was filtered through diatomaceous earth. The weight

of the resulting slightly cloudy liquid was 5.24 kg for a total yield of 53% from the original fruit;

3) Dry Ground Cranberry: The starting weight of berries was 10.57 kg. These previously frozen (@-40°C) were brought to a temperature of -1°C and then skin and seed were removed from the berries employing a Robot Coupe C120 extraction system (Jackson, MS). The mass of pomace was 9.51 kg and the mass of seeds/skins was 1.06 kg; for a total mass recovery of 100.0%. The pomace was then treated with a mixture of DP321 (145 μL) and with Crystalzyme PMLX (145 μL) @22°C for 12 hours. Following enzymatic liquifaction the resulting solution was filtered through diatomaceous earth. The weight of the resulting clear liquid was 8.04 kg for a total yield of 76% from the original fruit.

Conclusions

To our knowledge this study comprises the first complete chemical analysis of buffaloberry, choke cherry, dry ground and highbush cranberry and sea-buckthorn. The results from these analyses have shown that each of the berries are rich in fibre (mainly due to an abundance of polysaccharide material); and have relatively high levels of protein when compared to other fruits normally processed into juice (apple, orange, etc.). Sea-buckthorn was shown to be rich in lipid which could be a marketing problem for this berry and any value-added product produced from it. This work completed objective (a) of this study which was to "determine the chemical composition of a selection of fruits native to Saskatchewan".

During the chemical analysis of these berries we also developed two methods for the detection of chemical compounds which have been correlated with health promotion. Two of these classes of compounds which are commonly called nutraceuticals were anthocyanins and polyphenols.

The anthocyanin results clearly show that the major anthocyanin present in buffaloberry and choke cherry is cyanidin glucoside. In addition, the results show that the two cranberries native to Saskatchewan show anthocyanin patterns which are similar qualitatively to *Vaccinium macrocarpon* although the dry ground cranberry native to our Province is *Vaccinium vitis-idaea*, and the highbush cranberry is *Viburnum americanum*. We related the concentration of anthocyanins in Saskatchewan 'cranberry' to those in the

cranberry commonly used in fruit juice beverages (*Vaccinium macrocarpon*). This was accomplished by diluting all of the purees and the authentic cranberry juice to 6 °Brix; samples were then analyzed by our reverse phase high performance liquid chromatographic (RP-HPLC) method. The results show that the anthocyanin content of dry ground cranberry and highbush cranberry based on cyanidin galactoside (the anthocyanin present in the highest concentration) was higher in these berries when compared to authentic cranberry. In addition, both native 'cranberries' showed higher levels of cyanidin glucoside than was present in the authentic cranberry. Whereas the cyanidin glucoside concentration for buffaloberry and authentic cranberry were shown to be approximately equivalent.

Our research also clearly established the presence of polyphenols in all five fruit purees. We found appreciable levels of chlorogenic acid, catechin, epicatechin, and caffeic acid in both highbush and dry ground cranberries. These results compare favourably to those of apple juice which is currently being promoted for its role as a functional food (based on the presence of the antioxidant quercetin). In addition, we found the presence of catechin, epicatechin, and quercetin in buffaloberry and choke cherry; and catechin, epicatechin and kaempferol in sea-buckthorn berries. Aside from these identifiable (based on retention time comparisons to standards) polyphenols we also noted the presence of a variety of other hydrophobic compounds (which may be phenolics based on the combination of detection wavelength, stationary and mobile phases used) which appeared in the chromatogram but which we could not match to the standards which we ran in conjunction with these samples.

Anthocyanins and anthocyanidins have been identified for their possible role in tumour prevention, delay in aging/loss of memory and motor skills, reducing the risk of coronary disease, and the ability to alleviate/prevent urinary tract infection. Whereas polyphenols have been shown to be very good antioxidants which may impact a number of diseases/disorders/conditions that have been shown to be significantly affected by the administration of antioxidants. These include but are not limited to: cancer and preneoplastic conditions; cataracts; cardiovascular disorders; arthritis; reperfusion injury; and nervous system disorders. Our results show that these fruits contain appreciable quantities of these nutraceuticals and this portion of our research has addressed objective (c) ("nutraceutical identification in these fruits or their waste products from juice production") of our research proposal.

In general, juice production from raw fruit involves the following processing stages: (1) milling of the fruit to produce a pomace; (2) enzymatic treatment of the pomace (liquifaction) in order to breakdown cell wall polysaccharides; this treatment results in increased expression of juice from the fruit; (3) pressing of the enzymatically treated pomace; (4) filtration; (5) water removal from the filtered juice to produce a concentrate.

In this study we employed a Robot Coupe C120 extraction system for the removal of skin and seed from the five fruits which were the focal point of this research. This piece of equipment appears to be very efficient at skin and seed removal from each of the fruits examined with optimal pomace yield. Enzymatic treatment of the pomace was then investigated using six different commercial enzymes at two dosages levels at both low (<26°C) and high temperature (54°C). For each fruit a specific enzymes or group of enzymes which gave equivalent liquifaction, enzyme dosage, and liquefaction temperature was identified for a 125 g pomace sample. These 'optimum' conditions were then employed for scaled-up liquifaction of three fruits. Overall yields from these fruits were quite promising ranging from a low of 53% to a high of 76% from the actual fruit. The results obtained from these experiments address objective (b) of our research proposal ("examination of the processing ability of these fruits with respect to juice and puree production").

We did not have the time or financial resources to address objective (d) of the research proposal regarding the "identification of possible food ingredients from the waste products of juice production".

Future research which is important for the fruit industry of Saskatchewan to move into the national and international arena include: (1) ongoing funding for the analysis of fruit native to Saskatchewan with a particular emphasis on the effects of geographical location and climate on chemical composition; (2) elucidation of the unidentified polyphenolic compounds present in buffaloberry, choke cherry, dry ground and highbush cranberry, and sea-buckthorn; (3) examination of the economic feasibility of colour/nutraceutical extraction and stabilization from the skins of buffaloberry, choke cherry, dry ground and highbush cranberry.

E) Personnel

Ms Cindy Yu was the technical assistant working full time on this project from February of 1998 to February of 2000. Cindy joined the group when the previous research technician (Ms Karen Smith) working on this project left for a higher paying chemical research technician position. This change in personnel resulted in a significant disruption in the progress of this work as it was impossible to train Cindy in the two weeks notice given. It has taken a great deal of my time (Dr. Nicholas Low) to train both Karen and Cindy in the complex analytical techniques which we routinely employ for both the chemical and physical analysis of fruits. In addition to Karen and Cindy, two fourth year Applied Microbiology and Food Science undergraduate students worked on this project during the months of May to August: Ms. Genne Seto (1998) and Ms. Sherri Buckler (1999).

F) Acknowledgement

In media interviews I have gratefully acknowledged the financial support of ADF.

Table 1: Chemical Composition Data (1996 and 1997 Crops)

Blueberry (*Vaccinium angustifolium Ait.* or *V. myrtilloides*)

	°Brix	Sorbitol[1]	Glucose[1]	Fructose[1]	Sucrose[1]	pH	Moisture[1]	Ash[1]	Protein
Hudson Bay (1/1996)	12.7	0.002	6.14	6.27	0.23	3.2	84.3	0.21	0.51
Hudson Bay (2/1996)	12.2	0.001	5.77	6.04	0.13	3.7	83.6	0.24	0.51
Hudson Bay (1/1997)	12.6	0.002	5.72	6.14	0.28	3.4	84.6	0.29	0.38
Hudson Bay (2/1997)	12.9	0.002	5.88	6.11	0.23	3.5	84.2	0.15	0.47
La Ronge (1/1996)	12.4	0.001	6.15	6.34	0.18	3.3	83.1	0.22	0.33
La Ronge (2/1996)	12.2	0.002	6.06	6.45	0.19	33	86.7	0.34	0.62
La Ronge (3/1996)	12.5	0.002	5.77	6.31	0.09	3.1	80.8	0.09	0.84
La Ronge (4/1997)	12.9	0.002	6.11	6.57	0.07	3.2	83.1	0.19	0.41
La Ronge (5/1997)	12.8	0.002	5.18	5.45	0.23	3.4	85.2	0.20	0.45
Meadow Lake (1/1996)	11.2	0.002	4.97	5.01	0.26	3.4	87.2	0.31	0.47
Meadow Lake (2/1997)	11.7	0.001	4.67	4.89	0.31	3.2	86.8	0.25	0.22
Prince Albert (1/1996)	11.9	0.001	5.14	5.32	0.11	3.1	82.9	0.21	0.67
Prince Albert (2/1996)	11.2	0.002	5.07	5.33	0.26	32	83.5	0.23	0.74

Blueberry (continued)

		°Brix	Sorbitol[1]	Glucose[1]	Fructose[1]	Sucrose[1]	pH	Moisture[1]	Ash[1]	Protein
Prince Albert (3/1997)	21.0	12.3	0.001	5.87	6.05	0.34	3.2	82.0	0.36	0.44
Prince Albert (4/1997)	19.4	11.3	0.001	5.07	5.22	0.21	3.3	87.6	0.27	0.81

	Lipid[1]	Calcium[2]	Magnesium[2]	Potassium[2]	Sodium[2]	Malic[3]	Maleic[3]
Hudson Bay (1/1996)	0.09	33	93	533	32	48	ND
Hudson Bay (2/1996)	0.02	66	46	913	35	33	ND
Hudson Bay (1/1997)	0.01	57	64	828	37	46	ND
Hudson Bay (2/1997)	0.04	82	36	810	23	22	ND
La Ronge (1/1996)	0.06	51	43	419	33	33	ND
La Ronge (2/1996)	0.01	62	46	920	29	47	ND
La Ronge (3/1996)	0.07	27	66	709	31	40	ND
La Ronge (4/1997)	0.04	72	87	447	41	23	ND
La Ronge (5/1997)	0.03	58	55	623	21	35	ND
Meadow Lake (1/1996)	0.05	77	101	926	20	47	ND

Blueberry (continued)

		Lipid[1]	Calcium[2]	Magnesium[2]	Potassium[2]	Sodium[2]	Malic[3]	Maleic[3]
Meadow Lake (2/1997)		0.02	64	89	1031	32	26	ND
Prince Albert (1/1996)		0.03	51	75	1111	29	39	ND
Prince Albert (2/1996)		0.03	25	83	626	36	33	ND
Prince Albert (3/1997)	21.0	0.04	87	50	534	30	52	ND
Prince Albert (4/1997)	19.4	0.03	57	62	421	31	67	ND

	Citric[3]	Quinic[3]	Anthocyanins[3]	Starch	Fibre[4]
Hudson Bay (1/1996)	190	433	4.9	ND[5]	20.5
Hudson Bay (2/1996)	221	326	4.3	ND	21.2
Hudson Bay (1/1997)	110	375	3.7	ND	19.4
Hudson Bay (2/1997)	204	282	4.4	ND	22.6
La Ronge (1/1996)	96	161	2.7	ND	20.1
La Ronge (2/1996)	201	422	2.5	ND	19.8
La Ronge (3/1996)	207	317	2.6	ND	22.3

Blueberry (continued)

	Citric[3]	Quinic[3]	Anthocyanins[3]	Starch	Fibre[4]
La Ronge (4/1997)	94	272	4.7	ND[5]	21.0
La Ronge (5/1997)	193	179	4.5	ND	18.3
Meadow Lake (1/1996)	185	277	5.1	ND	20.2
Meadow Lake (2/1997)	182	402	4.8	ND	18.9
Prince Albert (1/1996)	223	199	5.2	ND	20.6
Prince Albert (2/1996)	103	285	4.1	ND	20.4
Prince Albert 21.0 (3/1997)	194	347	3.0	ND	18.8
Prince Albert 19.4 (4/1997)	203	302	4.2	ND	19.7

Buffaloberry (*Shepherdia argentea*)

	°Brix	Sorbitol[1]	Glucose[1]	Fructose[1]	Sucrose[1]	pH	Moisture[1]	Ash[1]	Protein
Outlook (1/1997)	22.3	ND	10.10	8.91	0.12	3.3	73.0	0.65	2.55
Outlook (2/1997)	18.5	0.002	7.41	6.96	0.12	3.5	75.8	0.54	2.34
Q-Valley/Lebret (1/1997)	24.6	ND	10.50	9.05	0.13	3.1	70.4	0.71	2.67
Regina (1/1997)	25.6	0.010	9.79	8.39	0.12	3.1	69.0	0.71	2.67

	Lipid[1]	Calcium[2]	Magnesium[2]	Potassium[2]	Sodium[2]	Malic[3]	Maleic[3]
Outlook (1/1997)	0.12	86	61	940	38	2064	ND
Outlook (2/1997)	0.06	88	92	1991	36	1706	ND
Q-Valley/Lebret (1/1997)	0.06	85	64	760	29	1155	ND
Regina (1/1997)	0.03	105	67	960	26	2076	ND

	Citric[3]	Quinic[3]	Anthocyanins[3]	Starch	Fibre[4]
Outlook (1/1997)	1346	730		ND[5]	27.4
Outlook (2/1997)	2100	846		ND	31.3
Q-Valley/Lebret (1/1997)	3333	931		ND	31.6
Regina (1/1997)	2987	710		ND	33.1

Choke Cherry (*Prunus virginiana*)

	°Brix	Sorbitol[1]	Glucose[1]	Fructose[1]	Sucrose[1]	pH	Moisture[1]	Ash[1]	Protein
Hudson Bay (1/1996)	20.7	3.11	7.45	6.27	0.10	4.2	64.6	0.81	1.01
Hudson Bay (2/1996)	23.2	3.29	7.44	6.47	0.03	4.0	65.8	0.64	1.11
Hudson Bay (3/1997)	20.7	2.88	6.78	6.11	0.10	4.2	63.0	0.86	0.97
Indian Head (1/1996)	22.6	3.10	7.22	6.58	0.08	4.3	62.6	0.89	1.08
Indian Head (2/1996)	20.9	2.98	7.44	6.81	0.10	4.2	62.4	0.91	0.97
Indian Head (1/1997)	21.3	3.06	7.12	6.32	0.09	4.3	62.3	0.76	1.15
Indian Head (2/1997)	21.7	3.10	7.29	6.15	0.05	4.4	63.5	0.88	1.13
La Ronge (1/1996)	20.8	3.22	7.75	6.74	0.12	4.2	63.1	0.82	1.13
La Ronge (2/1996)	22.2	2.97	7.06	6.65	0.10	4.3	64.1	0.74	1.30
La Ronge (3/1996)	21.5	3.05	7.47	6.51	0.09	4.1	63.8	0.89	0.84
La Ronge (4/1997)	20.9	2.45	6.71	5.97	0.07	4.2	66.8	0.95	1.20
La Ronge (5/1997)	22.8	2.02	5.68	5.01	0.23	4.4	60.5	0.79	1.05

Choke Cherry (continued)

	°Brix	Sorbitol[1]	Glucose[1]	Fructose[1]	Sucrose[1]	pH	Moisture[1]	Ash[1]	Protein
Nipawin (1/1996)	20.9	2.88	7.74	6.07	0.11	4.1	62.9	0.91	1.04
Nipawin (2/1996)	21.2	3.08	7.07	6.33	0.06	4.2	62.8	0.73	0.94
Nipawin (3/1997)	21.0	2.34	6.12	5.65	0.04	4.2	62.0	0.96	1.04
Nipawin (4/1997)	19.4	3.11	7.07	5.92	0.10	4.1	66.6	0.87	1.00
Outlook (1/1996)	23.5	3.02	7.54	6.19	0.04	4.2	62.8	0.76	0.94
Outlook (2/1996)	23.1	2.78	7.04	5.97	0.08	4.3	62.1	1.03	1.13
Outlook (3/1997)	19.8	2.66	6.34	4.98	0.04	4.2	63.8	0.74	1.02
Outlook (4/1997)	20.3	3.00	5.89	5.12	0.12	4.3	63.1	0.97	1.07
Prince Albert (1/1996)	19.1	2.33	5.71	5.18	0.05	4.1	62.7	0.68	0.94
Prince Albert (2/1996)	20.7	2.44	6.14	5.48	0.08	4.2	63.9	0.81	1.03
Prince Albert (3/ 1997)	21.7	2.77	6.89	6.13	0.13	4.4	63.0	0.90	0.98
Saskatoon (1/1996)	22.2	3.02	7.11	6.57	0.03	4.0	61.2	0.68	0.73
Saskatoon (2/1997)	22.8	2.88	6.59	6.03	0.10	4.2	64.4	0.89	0.92
Tisdale (1/1996)	24.1	3.09	7.10	5.58	0.03	4.3	65.2	0.55	1.04
Tisdale (2/1997)	22.1	2.86	7.33	6.57	0.06	4.2	64.1	0.65	0.89

Choke Cherry (continued)

	Lipid[1]	Calcium[2]	Magnesium[2]	Potassium[2]	Sodium[2]	Malic[3]	Maleic[3]
Hudson Bay (1/1996)	0.02	89	40	940	15	422	ND
Hudson Bay (2/1996)	0.03	45	84	907	33	265	ND
Hudson Bay (3/1997)	0.02	77	106	533	28	305	ND
Indian Head (1/1996)	0.03	112	166	1060	17	121	ND
Indian Head (2/1996)	0.01	79	64	589	22	144	ND
Indian Head (1/1997)	0.01	55	48	790	45	392	ND
Indian Head (2/1997)	0.03	41	107	977	40	246	ND
La Ronge (1/1996)	0.05	88	92	861	31	118	ND
La Ronge (2/1996)	0.04	66	69	1023	19	306	ND
La Ronge (3/1996)	0.04	156	88	613	22	298	ND
La Ronge (4/1997)	0.01	45	36	590	37	401	ND
La Ronge (5/1997)	0.01	102	169	980	33	245	ND
Nipawin (1/1996)	0.02	105	107	895	16	333	ND
Nipawin (2/1996)	0.02	93	96	775	27	270	ND

Choke Cherry (continued)

	Lipid[1]	Calcium[2]	Magnesium[2]	Potassium[2]	Sodium[2]	Malic[3]	Maleic[3]
Nipawin (3/1997)	0.01	37	34	802	40	196	ND
Nipawin (4/1997)	0.03	85	84	930	19	351	ND
Outlook (1/1996)	0.03	69	100	870	22	307	ND
Outlook (2/1996)	0.04	101	88	612	38	169	ND
Outlook (3/1997)	0.01	84	134	1130	30	250	ND
Outlook (4/1997)	0.01	99	55	895	19	221	ND
Prince Albert (1/1996)	0.02	39	102	960	41	318	ND
Prince Albert (2/1996)	0.01	102	105	941	20	177	ND
Prince Albert (3/ 1997)	0.04	88	83	901	25	406	ND
Saskatoon (1/1996)	0.02	65	74	813	31	231	ND
Saskatoon (2/1997)	0.01	101	110	649	18	375	ND
Tisdale (1/1996)	0.04	115	167	1004	34	400	ND
Tisdale (2/1997)	0.04	80	64	732	30	237	ND

Choke Cherry (continued)

	Citric[3]	Quinic[3]	Anthocyanins[3]	Starch	Fibre[4]
Hudson Bay (1/1996)	895	109	44	ND[5]	28.0
Hudson Bay (2/1996)	721	135	40	ND	28.8
Hudson Bay (3/1997)	803	107	36	ND	28.6
Indian Head (1/1996)	660	88	47	ND	24.5
Indian Head (2/1996)	517	240	51	ND	27.5
Indian Head (1/1997)	881	219	60	ND	25.0
Indian Head (2/1997)	620	141	29	ND	25.4
La Ronge (1/1996)	533	188	32	ND	29.3
La Ronge (2/1996)	540	96	29	ND	28.7
La Ronge (3/1996)	504	59	28	ND	29.2
La Ronge (4/1997)	497	74	36	ND	24.1
La Ronge (5/1997)	822	92	39	ND	26.0
Nipawin (1/1996)	670	84	27	ND	25.5

Choke Cherry (continued)

	Citric[3]	Quinic[3]	Anthocyanins[3]	Starch	Fibre[4]
Nipawin (2/1996)	719	194	36	ND[5]	27.8
Nipawin (3/1997)	701	137	34	ND	28.2
Nipawin (4/1997)	665	205	44	ND	28.4
Outlook (1/1996)	553	99	40	ND	23.1
Outlook (2/1996)	840	78	38	ND	27.5
Outlook (3/1997)	921	180	34	ND	25.2
Outlook (4/1997)	600	176	25	ND	29.0
Prince Albert (1/1996)	486	203	32	ND	29.1
Prince Albert (2/1996)	644	191	35	ND	26.3
Prince Albert (3/ 1997)	700	188	43	ND	27.8
Saskatoon (1/1996)	810	165	44	ND	28.0
Saskatoon (2/1997)	597	200	21	ND	28.4
Tisdale (1/1996)	616	175	37	ND	23.1
Tisdale (2/1997)	400	89	54	ND	26.5

Dry Ground Cranberry/Lingonberry (*Vaccinium vitis-idaea L.*)

	°Brix	Sorbitol[1]	Glucose[1]	Fructose[1]	Sucrose[1]	pH	Moisture[1]	Ash[1]	Protein
Hudson Bay (1/1996)	11.0	0.002	2.82	3.31	1.3	2.6	85.5	0.21	0.51
Hudson Bay (1/1996)	10.8	0.001	2.90	3.41	1.1	2.7	86.0	0.34	0.65
Hudson Bay (2/1997)	9.8	0.001	2.55	3.10	1.2	2.5	88.1	0.21	0.41
Hudson Bay (2/1997)	11.2	0.001	2.67	3.45	0.93	2.6	85.1	0.15	0.67
La Ronge (1/1996)	8.9	0.001	2.35	2.87	1.0	2.7	89.7	0.34	0.48
La Ronge (2/1997)	10.8	0.002	2.51	2.97	1.4	2.5	86.3	0.26	0.36
Outlook (1/1996)	11.0	0.001	2.43	3.64	1.2	2.6	85.5	0.31	0.64
Outlook (2/1997)	11.1	0.001	2.68	3.02	1.3	2.6	86.4	0.24	0.62

Dry Ground Cranberry (continued)

	Lipid[1]	Calcium[2]	Magnesium[2]	Potassium[2]	Sodium[2]	Malic[3]	Maleic[3]
Hudson Bay (1/1996)	0.10	156	69	820	34	392	ND
Hudson Bay (1/1996)	0.08	115	92	523	31	246	ND
Hudson Bay (2/1997)	0.10	88	86	996	27	488	ND
Hudson Bay (2/1997)	0.11	145	57	863	24	135	ND
La Ronge (1/1996)	0.10	102	107	700	33	502	ND
La Ronge (2/1997)	0.10	179	61	760	25	338	ND
Outlook (1/1996)	0.10	143	84	907	20	255	ND
Outlook (2/1997)	0.09	118	58	778	36	424	ND

Dry Ground Cranberry (continued)

	Citric[3]	Quinic[3]	Anthocyanins[3]	Starch	Fibre[4]
Hudson Bay (1/1996)	2120	2040	97	ND[5]	29.2
Hudson Bay (1/1996)	1980	1715	92	ND	26.4
Hudson Bay (2/1997)	2789	1890	102	ND	27.7
Hudson Bay (2/1997)	2654	2445	87	ND	27.5
La Ronge (1/1996)	1620	2102	93	ND	25.2
La Ronge (2/1997)	2964	2437	71	ND	27.8
Outlook (1/1996)	2525	1820	94	ND	25.5
Outlook (2/1997)	2009	1811	105	ND	29.9

Highbush Cranberry (*Virburnum americanum* or *V. trilobum*)

	°Brix	Sorbitol[1]	Glucose[1]	Fructose[1]	Sucrose[1]	pH	Moisture[1]	Ash[1]	Protein
Hudson Bay (1/1996)	18.7	0.006	5.87	6.10	0.33	3.0	72.5	0.61	1.11
Hudson Bay (2/1996)	17.5	0.002	5.47	5.76	0.18	3.0	73.6	0.76	1.46
Indian Head (1/1996)	17.7	0.009	5.35	5.84	0.20	2.9	72.5	0.53	1.35
Indian Head (2/1997)	19.2	0.010	6.06	6.66	0.43	3.0	70.8	0.76	1.06
La Ronge (1/1996)	18.5	0.008	6.34	6.71	0.29	3.1	73.1	0.64	1.41
La Ronge (2/1997)	18.2	0.002	6.00	6.52	0.16	3.0	72.8	0.50	1.20
Meadow Lake (1/1996)	18.2	0.010	5.97	6.32	0.46	3.2	74.2	0.61	1.57
Meadow Lake (2/1997)	17.7	0.009	4.97	5.44	0.14	3.1	71.6	0.55	1.22
Outlook (1/1996)	17.9	0.004	5.09	5.44	0.37	3.1	73.8	0.49	1.43
Outlook (2/1997)	18.3	0.007	6.18	6.55	0.33	2.9	72.5	0.50	1.03
Prince Albert (1/1996)	18.9	0.006	6.44	6.82	0.21	3.1	72.9	0.31	1.44
Prince Albert (2/1997)	18.2	0.011	6.37	6.83	0.26	3.0	73.5	0.47	1.08
Saskatoon (1/1996)	17.7	0.008	5.38	5.61	0.17	2.9	72.5	0.70	0.95
Saskatoon (2/1997)	18.5	0.006	6.43	6.76	0.28	3.1	72.1	0.51	1.50

Highbush Cranberry (continued)

	Lipid[1]	Calcium[2]	Magnesium[2]	Potassium[2]	Sodium[2]	Malic[3]	Maleic[3]
Hudson Bay (1/1996)	0.10	45	161	1839	30	4278	ND
Hudson Bay (2/1996)	0.10	54	176	1780	41	5284	ND
Indian Head (1/1996)	0.09	37	104	1472	39	5525	ND
Indian Head (2/1996)	0.03	66	169	1342	50	4078	ND
La Ronge (1/1996)	0.10	86	97	2290	21	4731	ND
La Ronge (2/1997)	0.09	76	130	1208	41	3120	ND
Meadow Lake (1/1996)	0.08	47	156	2986	22	4789	ND
Meadow Lake (2/1997)	0.10	44	144	1914	31	2116	ND
Outlook (1/1996)	0.10	105	114	1730	17	3728	ND
Outlook (2/1997)	0.08	65	135	1893	18	2727	ND
Prince Albert (1/1996)	0.09	29	128	1148	40	4729	ND
Prince Albert (2/1997)	0.09	87	168	1626	13	3535	ND
Saskatoon (1/1996)	0.10	58	106	1910	29	1972	ND
Saskatoon (2/1997)	0.07	43	157	1280	21	3875	ND

Highbush Cranberry (continued)

	Citric[3]	Quinic[3]	Anthocyanins[3]	Starch	Fibre[4]
Hudson Bay (1/1996)	ND	231	20.1	ND[5]	34.7
Hudson Bay (2/1996)	ND	240	14.5	ND	38.2
Indian Head (1/1996)	ND	168	14.9	ND	36.5
Indian Head (2/1997)	ND	319	21.6	ND	38.7
La Ronge (1/1996)	ND	286	20.7	trace	37.3
La Ronge (2/1997)	ND	176	15.7	trace	38.1
Meadow Lake (1/1996)	ND	174	16.5	ND	35.8
Meadow Lake (2/1997)	ND	224	18.4	ND	36.2
Outlook (1/1996)	ND	215	15.1	ND	34.3
Outlook (2/1997)	ND	235	21.1	ND	37.7
Prince Albert (1/1996)	ND	309	18.2	ND	39.4
Prince Albert (2/1997)	ND	217	16.8	ND	37.4
Saskatoon (1/1996)	ND	357	19.6	ND	37.9
Saskatoon (2/1997)	ND	343	20.7	ND	38.5

Sea-buckthorn Berry (*Hippophae rhamnoides L.*)

	°Brix	Sorbitol[1]	Glucose[1]	Fructose[1]	Sucrose[1]	pH	Moisture[1]	Ash[1]	Protein
Outlook (1/1997)	11.6	0.010	4.66	1.71	2.21	3.1	73.9	0.47	2.10
Saskatoon (1/1997)	12.0	0.018	4.95	2.10	2.31	3.1	72.8	0.55	1.87

	Lipid[1]	Calcium[2]	Magnesium[2]	Potassium[2]	Sodium[2]	Malic[3]	Maleic[3]
Outlook (1/1997)	1.48	93	40	3010	36	2213	ND
Saskatoon (1/1997)	1.16	112	59	3357	21	3080	ND

	Citric[3]	Quinic[3]	β-Carotene[2]	Lutein[2]	Fibre[4]
Outlook (1/1997)	222	2611	33	21	33.0
Saskatoon (1/1997)	190	1922	39	25	32.2

[1]g/100g;
[2]parts per million (mg/1000g);
[3]mg/100g;
[4]g/100g; analysis performed on whole berry (excluding seeds);
[5]not detected;

Table 1. Chemical Composition Data for Fruit Harvested in 1998 (pomace)

	°Brix	Sorbitol[1]	Glucose[1]	Fructose[1]	Sucrose[1]	pH	Moisture[1]	Ash[1]	Protein
Buffaloberry	19.6	nd[2]	10.18	8.20	0.10	3.3	74.3	0.69	1.56
Choke Cherry	20.4	2.10	7.46	6.27	0.05	4.0	75.4	0.71	1.18
Dry Ground Cranberry	11.0	0.002	2.63	3.39	1.28	2.6	86.5	0.20	0.36
Highbush Cranberry	13.1	0.006	3.80	4.60	0.15	3.4	84.0	0.74	0.24
Sea-buckthorn	12.0	0.012	4.97	1.57	2.16	3.2	84.4	0.51	0.91

[1]g/100g
[2]not detected

Table 1: (Fruit Harvested in 1998 Continued)

	Calcium[3]	Magnesium[3]	Potassium[3]	Sodium[3]	Malic[4]	Quinic[4]	Citric[4]
Buffaloberry	86	65	930	32	1180	810	2170
Choke Cherry (2/1996)	115	84	1650	25	320	150	850
Dry Ground Cranberry	33	107	700	31	90	1590	2790
Highbush Cranberry	45	166	1839	41	1810	390	nd
Sea-buckthorn	93	40	3010	36	1480	2370	200

[3]parts per million (mg/1000g)
[4]mg/100g

Table 1. Chemical Composition Data for Fruit Harvested in 1998 (Whole Berry - Seed)

	°Brix	Moisture[1]	Ash[1]	Protein[1]	Lipid[1]	Total Dietary Fibre[1]
Buffaloberry	19.6	72.2	0.06	1.97	0.06	26.0
Choke Cherry	20.4	66.8	0.67	2.61	0.03	26.1
Dry Ground Cranberry	11.0	84.2	0.20	0.48	0.11	25.0
Highbush Cranberry	13.1	71.8	0.73	1.19	0.10	18.7
Sea-buckthorn	12.0	69.3	0.48	2.10	2.01	25.3

[1]g/100g

Table 1: (Fruit Harvested in 1998 Continued)

	Lipid[1]	Fibre[5]
Buffaloberry	0.09	25.8
Chokecherry (2/1996)	0.05	26.4
Dry Ground Cranberry	0.04	19.0
Highbush Cranberry	0.05	21.0
Seabuckthorn	3.09	22.3

[5]g/100g; analysis performed on the whole berry (excluding seeds)

Table 2. **A Qualitative and Quantitative Comparison of Anthocyanins in Fruit (all @ 6 °Brix) Native to Sasktachewan with Authentic Cranberry**

Anthocyanin	Authentic Cranberry[1]	Buffaloberry	Choke Cherry	Dry Gound Cranberry	Highbush Cranberry
cyanidin-galactoside	[2]5.6 x 10^6	nd[3]	nd	>[4]	>
cyanidin-glucoside	3.2 x 10^5	same	same	>	>
cyanidin-arabinoside	5.1 x 10^6	nd	nd	<[5]	<
peonidin-galactoside	7.4 x 10^6	nd	nd	<	<
peonidin-arabinoside	4.4 x 10^6	nd	nd	>	<

[1] *Vaccinium macrocarpon*
[2] area
[3] not detected
[4] peak area greater than that observed in the authentic cranberry sample
[5] peak area less than that observed in the authentic cranberry sample

Table 3. Quantitative Results for Cyanidin-galactoside and Cyanidin-glucoside in Native Saskatchewan Fruits and Authentic Cranberry

Anthocyanin	Authentic Cranberry	Buffaloberry	Choke Cherry	Dry Gound Cranberry	Highbush Cranberry
cyanidin-galactoside	~50 ppm	nd[1]	nd	~900 ppm	~300 ppm
cyanidin-glucoside	<5 ppm	<5 ppm	<5 ppm	~135 ppm	~40 ppm

[1]not detected

Table 4. Temperature and pH Working Ranges for Enzymes Used in the Liquifaction of Fruits Native to Saskatchewan

Enzyme	Working pH Range	Working Temperature Range
Biopectinase CCM	2.5 to 5.0	2 to 60 °C (50 °C optimal)
Biopectinase HM/P	2.5 to 5.0	10 to 60 °C (50 to 60 °C optimal)
Biopectinase 300	2.0 to 6.5	2 to 66 °C
Crystalzyme PMLX	3.5 to 5.0	2 to 60 °C (50 °C optimal)
Crystalzyme 100XL	3.5 to 5.0	10 to 60 °C (50 °C optimal)
DP321	4.0 to 6.0	15 to 50 °C (40 to 50 °C optimal)

Table 5: Liquifaction of Fruit Pomace Using Commercial Enzymes and the Resulting Viscosity (Torque [S]) of the Pomace as a Function of Enzyme Dosage and Temperature

Berry-buffaloberry

Torque of non-enzyme treated puree=25.2

Enzyme	Temperature (°C)	Puree Mass (g)	Torque (S) High Dose	Torque (S) Low Dose
Crystalzyme PMLX	22	125	10.9	9.8
Crystalzyme PMLX	35	125	18.8	22.2
Crystalzyme PMLX	55	125	34.8	34.5
Crystalzyme 100XL	22	125	18.1	13.2
Crystalzyme 100XL	35	125	21.5	21.5
Crystalzyme 100XL	55	125	34.5	18.5
Biopectinase CCM	22	125	19.9	19.9
Biopectinase CCM	35	125	17.1	14.3
Biopectinase CCM	55	125	27.8	34.2
Biopectinase HM/P	22	125	20.6	20.8
Biopectinase HM/P	35	125	26.8	29.2
Biopectinase HM/P	55	125	24.0	29.2
Biopectinase 300	22	124	18.5	24.3
Biopectinase 300	35	125	22.0	18.6
Biopectinase 300	55	125	34.5	27.8
DP321	22	125	23.0	21.5
DP321	35	125	33.5	31.8
DP321	55	125	33.5	44.6

Table 5: Continued

Berry-chokecherry

Torque (S) of non-enzyme treated puree=51.5

Enzyme	Temperature (°C)	Puree Mass (g)	Torque (S) High Dose	Torque (S) Low Dose
Crystalzyme PMLX	22	125	29.9	25.3
Crystalzyme PMLX	35	125	35.5	33.8
Crystalzyme PMLX	55	125	32.8	33.3
Crystalzyme 100XL	22	125	20.9	33.4
Crystalzyme 100XL	35	125	28.1	24.9
Crystalzyme 100XL	55	125	39.5	45.6
Biopectinase CCM	22	125	29.8	30.8
Biopectinase CCM	35	125	26.8	26.9
Biopectinase CCM	55	125	37.3	46.0
Biopectinase HM/P	22	125	42.7	43.9
Biopectinase HM/P	35	125	36.9	29.7
Biopectinase HM/P	55	125	59.2	39.0
Biopectinase 300	22	125	35.0	34.5
Biopectinase 300	35	125	23.0	24.5
Biopectinase 300	55	125	28.8	37.7
DP321	22	125	18.1	18.6
DP321	35	125	27.7	31.2
DP321	55	125	64.0	47.5

Table 5: Continued

Berry-dried ground cranberry

Torque (S) of non-enzyme treated puree=10.0

Enzyme	Temperature (°C)	Puree Mass (g)	Torque (S) High Dose	Torque (S) Low Dose
Crystalzyme PMLX	22	125	5.2	6.5
Crystalzyme PMLX	35	125	6.7	6.9
Crystalzyme PMLX	55	125	8.5	8.1
Crystalzyme 100XL	22	125	7.9	8.5
Crystalzyme 100XL	35	125	7.9	6.0
Crystalzyme 100XL	55	125	8.6	7.0
Biopectinase CCM	22	125	14.2	14.5
Biopectinase CCM	35	125	5.8	5.0
Biopectinase CCM	55	125	7.1	8.5
Biopectinase HM/P	22	125	10.0	9.6
Biopectinase HM/P	35	125	7.0	8.9
Biopectinase HM/P	55	125	7.0	7.9
Biopectinase 300	22	125	6.5	6.8
Biopectinase 300	35	125	6.5	6.8
Biopectinase 300	55	125	8.2	10.0
DP321	22	125	5.5	6.0
DP321	35	125	8.8	7.8
DP321	55	125	9.3	9.4

Table 5: Continued

Berry- high bush cranberry

Torque (S) of non-enzyme treated puree=16.2

Enzyme	Temperature (°C)	Puree Mass (g)	Torque (S) High Dose	Torque (S) Low Dose
Crystalzyme PMLX	22	125	12.2	13.1
Crystalzyme PMLX	35	125	12.2	12.8
Crystalzyme PMLX	55	125	11.9	13.8
Crystalzyme 100XL	22	125	12.2	12.5
Crystalzyme 100XL	35	125	11.4	11.9
Crystalzyme 100XL	55	125	13.7	10.3
Biopectinase CCM	22	125	12.8	13.5
Biopectinase CCM	35	125	12.3	15.8
Biopectinase CCM	55	125	13.2	15.2
Biopectinase HM/P	22	125	14.5	15.6
Biopectinase HM/P	35	125	14.1	12.1
Biopectinase HM/P	55	125	16.5	16.5
Biopectinase 300	22	125	12.0	12.0
Biopectinase 300	35	125	12.0	12.8
Biopectinase 300	55	125	14.5	14.5
DP321	22	125	15.0	15.5
DP321	35	125	17.8	16.1
DP321	55	125	18.8	19.8

Table 5: Continued

Berry-seabuckthorn

Torque (S) of non-enzyme treated puree=4.0

Enzyme	Temperature (°C)	Puree Mass (g)	Torque (S) High Dose	Torque (S) Low Dose
Crystalzyme PMLX	22	125	3.8	3.8
Crystalzyme PMLX	35	125	3.1	3.7
Crystalzyme PMLX	55	125	2.8	2.6
Crystalzyme 100XL	22	125	3.0	2.8
Crystalzyme 100XL	35	125	4.0	4.6
Crystalzyme 100XL	55	125	2.8	3.8
Biopectinase CCM	22	125	2.8	3.3
Biopectinase CCM	35	125	2.6	2.8
Biopectinase CCM	55	125	2.3	2.5
Biopectinase HM/P	22	125	3.7	3.1
Biopectinase HM/P	35	125	2.7	2.8
Biopectinase HM/P	55	125	2.6	2.8
Biopectinase 300	22	125	3.0	2.0
Biopectinase 300	35	125	2.5	3.8
Biopectinase 300	55	125	1.5	1.9
DP321	22	125	2.1	1.8
DP321	35	125	2.6	2.8
DP321	55	125	4.8	3.8

Table 5: Continued

Seabuckthorn

Enzyme	Temperature (°C)	Viscosity	ShearRate (sec^{-1})	Shear Stress ($dyne/cm^2$)
Crystalzyme PMLX	22	41.80	328.33	137.18
Crystalzyme PMLX	35	34.13	328.33	111.91
Crystalzyme PMLX	55	28.62	328.33	93.86
Crystalzyme 100XL	22	30.80	328.33	101.08
Crystalzyme 100XL	35	44.03	328.33	144.4
Crystalzyme 100XL	55	30.80	328.33	101.08
Biopectinase CCM	22	30.80	328.33	101.08
Biopectinase CCM	35	28.62	328.33	93.86
Biopectinase CCM	55	25.32	328.33	83.03
Biopectinase HM/P	22	34.13	328.33	111.91
Biopectinase HM/P	35	29.72	328.33	97.47
Biopectinase HM/P	55	28.62	328.33	93.86
Biopectinase 300	22	22.02	328.33	72.2
Biopectinase 300	35	27.52	328.33	90.25
Biopectinase 300	55	16.51	328.33	54.15
DP321	22	19.81	328.33	64.98
DP321	35	28.62	328.33	93.86
DP321	55	41.80	328.33	137.18

Table 5: Continued

Dried Ground Cranberry

Enzyme	Temperature (°C)	Viscosity	ShearRate (sec^{-1})	Shear Stress ($dyne/cm^2$)
Crystalzyme PMLX	22	57.24	328.33	187.72
Crystalzyme PMLX	35	73.76	328.33	241.19
Crystalzyme PMLX	55	89.17	328.33	292.41
Crystalzyme 100XL	22	86.97	328.33	285.19
Crystalzyme 100XL	35	66.05	328.33	216.6
Crystalzyme 100XL	55	77.06	328.33	252.7
Biopectinase CCM	22	156.32	328.33	512.62
Biopectinase CCM	35	55.04	328.33	180.5
Biopectinase CCM	55	78.16	328.33	256.31
Biopectinase HM/P	22	105.68	328.33	346.56
Biopectinase HM/P	35	77.06	328.33	252.7
Biopectinase HM/P	55	77.06	328.33	252.7
Biopectinase 300	22	71.55	328.33	234.65
Biopectinase 300	35	71.55	328.33	234.65
Biopectinase 300	55	90.27	328.33	296.02
DP321	22	60.55	328.33	198.55
DP321	35	85.86	328.33	281.58
DP321	55	102.38	328.33	335.73

Table 5: Continued

Chokecherry

Enzyme	Temperature (°C)	Viscosity	ShearRate (sec^{-1})	Shear Stress ($dyne/cm^2$)
Crystalzyme PMLX	22	278.51	328.33	913.33
Crystalzyme PMLX	35	372.08	328.33	1220.18
Crystalzyme PMLX	55	361.07	328.33	1184.08
Crystalzyme 100XL	22	230.07	328.33	754.49
Crystalzyme 100XL	35	274.11	328.33	898.89
Crystalzyme 100XL	55	434.83	328.33	1425.95
Biopectinase CCM	22	328.05	328.33	1075.78
Biopectinase CCM	35	295.02	328.33	967.48
Biopectinase CCM	55	410.61	328.33	1346.53
Biopectinase HM/P	22	470.05	328.33	1541.47
Biopectinase HM/P	35	326.95	328.33	1072.17
Biopectinase HM/P	55	429.32	328.33	1407.90
Biopectinase 300	22	379.79	328.33	1245.45
Biopectinase 300	35	253.19	328.33	830.30
Biopectinase 300	55	317.04	328.33	1039.68
DP321	22	199.25	328.33	653.41
DP321	35	304.93	328.33	999.97
DP321	55	522.89	328.33	1714.75

Table 5: Continued Highbush Cranberry

Enzyme	Temperature (°C)	Viscosity	ShearRate (sec^{-1})	Shear Stress ($dyne/cm^2$)
Crystalzyme PMLX	22	134.30	328.33	440.42
Crystalzyme PMLX	35	134.30	328.33	440.42
Crystalzyme PMLX	55	131.00	328.33	429.59
Crystalzyme 100XL	22	134.30	328.33	440.42
Crystalzyme 100XL	35	125.49	328.33	411.54
Crystalzyme 100XL	55	113.39	328.33	371.83
Biopectinase CCM	22	140.91	328.33	462.08
Biopectinase CCM	35	135.40	328.33	444.03
Biopectinase CCM	55	145.31	328.33	476.52
Biopectinase HM/P	22	159.62	328.33	523.45
Biopectinase HM/P	35	133.20	328.33	436.81
Biopectinase HM/P	55	181.64	328.33	595.65
Biopectinase 300	22	132.10	328.33	433.20
Biopectinase 300	35	132.10	328.33	433.20
Biopectinase 300	55	159.62	328.33	523.45
DP321	22	165.12	328.33	541.50
DP321	35	177.23	328.33	581.21
DP321	55	206.96	328.33	678.68

Table 5: Continued

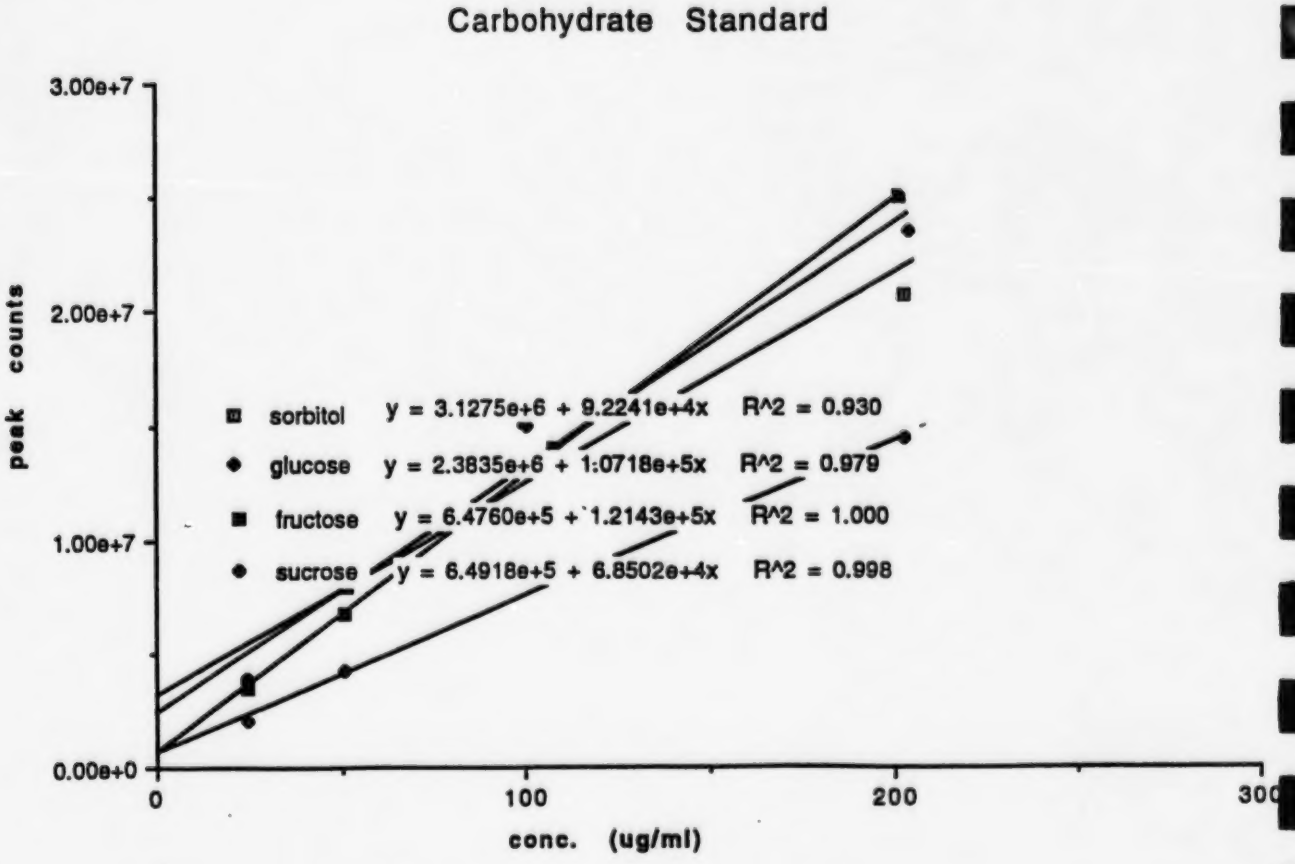
Buffaloberry

Enzyme	Temperature (°C)	Viscosity	ShearRate (sec^{-1})	Shear Stress ($dyne/cm^2$)
Crystalzyme PMLX	22	107.88	328.33	353.78
Crystalzyme PMLX	35	206.96	328.33	678.68
Crystalzyme PMLX	50	379.79	328.33	1245.45
Crystalzyme 100XL	22	145.31	328.33	476.52
Crystalzyme 100XL	35	236.68	328.33	776.15
Crystalzyme 100XL	50	203.65	328.33	667.85
Biopectinase CCM	22	219.06	328.33	718.39
Biopectinase CCM	35	157.42	328.33	516.23
Biopectinase CCM	50	306.03	328.33	1003.58
Biopectinase HM/P	22	226.77	328.33	743.66
Biopectinase HM/P	35	295.02	328.33	967.48
Biopectinase HM/P	50	264.20	328.33	866.4
Biopectinase 300	22	203.65	328.33	667.85
Biopectinase 300	35	204.75	328.33	671.46
Biopectinase 300	50	306.03	328.33	1003.58
DP321	22	236.68	328.33	776.15
DP321	35	350.06	328.33	1147.98
DP321	50	368.78	328.33	1209.35

Appendix A: Selected Representative Chromatograms and Standard Curves for Carbohydrates, Organic Acids and Anthocyanins

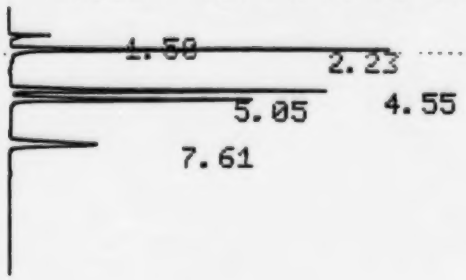
CHO standard

Column 1	conc.	sorbitol	g	glucose	f	fructose
Standards Mar 19/98						
sorbitol	24.340	3724974	24.480	3916996	24.190	3455030
	50.700	7853590	51.000	7975063	50.400	6768817
	100.000	15138939	101.000	14921823	108.000	14005377
	202.800	20645029	204.000	23498401	201.600	25011517
sucrose	24.290	2065951				
	50.600	4209813				
	106.000	8218378				
	202.400	14358810				



Run with new column

CHANNEL A INJECT 03/24/98 10:15:52



24ppm mixed stnd (CHO)
from Mar. 19/98

03/24/98 10:15:52 CH= "A" PS= 1.

FILE 0. METHOD 0. RUN 354 INDEX 354

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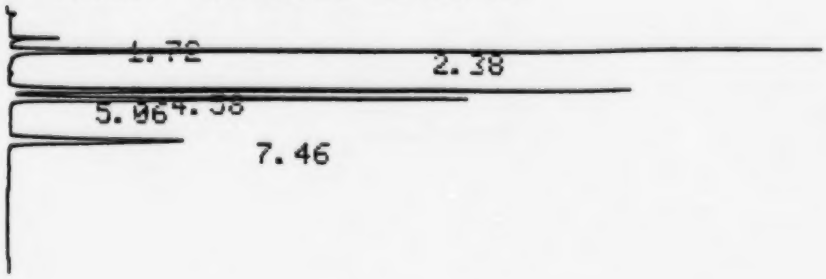
1	1.347	1.5	179789	01
2	27.918	2.23	3724974	01
3	29.357	4.55	3916996	01
4	25.894	5.05	3455030	01
5	15.484	7.61	2065951	01
TOTAL	100.		13342740	

CHANNEL A INJECT 03/24/98 11:14:49



50ppm mixed stnd (CHO)
from Mar. 19/98

03/24/98 11:14:49 CH= "A" PS= 1.

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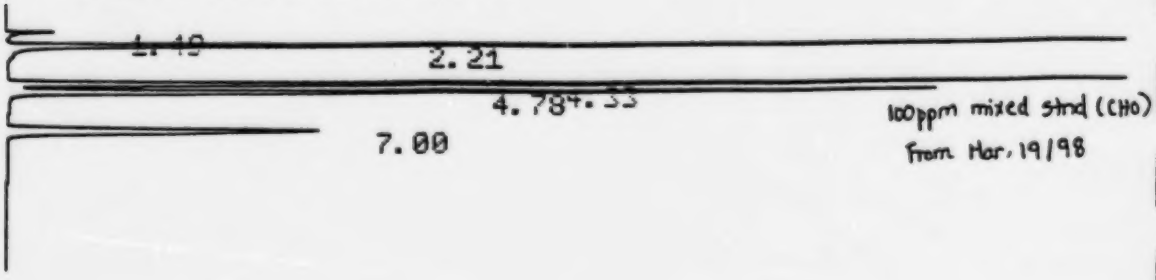
PEAK#	AREA%	RT	AREA	BC
1	0.693	1.72	186969	01
2	29.094	2.38	7853590	01
3	29.544	4.58	7975063	02
4	25.075	5.06	6768817	03
5	15.595	7.46	4209813	01
TOTAL	100.		26994252	

CHANNEL A INJECT 03/24/98 11:30:45

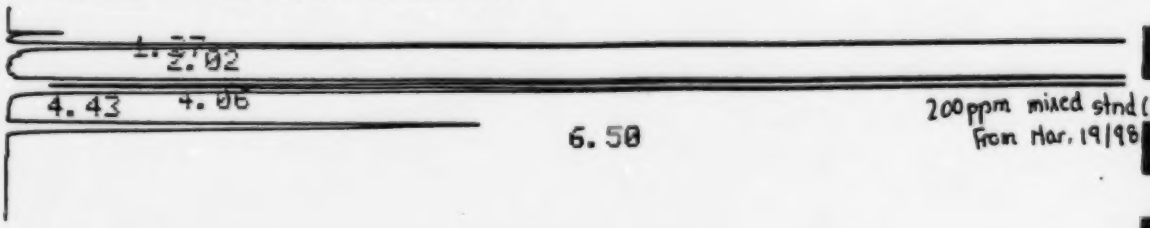


03/24/98 11:30:45 CH= "A" PS= 1.

FILE 0. METHOD 0. RUN 356 INDEX 356

PEAK#	AREA%	RT	AREA	BC
1	0.402	1.49	210997	01
2	28.839	2.21	15138939	01
3	28.425	4.33	14921823	02
4	26.679	4.78	14005377	03
5	15.655	7.	8218378	01
TOTAL	100.		52495514	

CHANNEL A INJECT 03/24/98 12:54:09



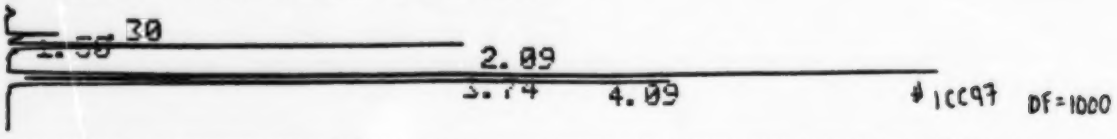
03/24/98 12:54:09 CH= "A" PS= 1.

FILE 0. METHOD 0. RUN 357 INDEX 357

PEAK#	AREA%	RT	AREA	BC
1	0.261	1.37	218602	01
2	24.656	2.02	20645029	01
3	28.064	4.06	23498401	02
4	29.871	4.43	25011517	03
5	17.148	6.5	14358810	01
TOTAL	100.		83732359	

Glucose, Fructose, Sorbitol

CHANNEL A INJECT 03/20/98 10:19:05

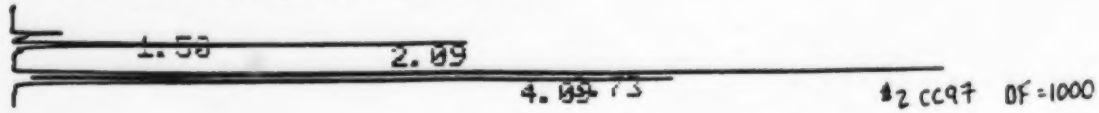


03/20/98 10:19:05 CH= "A" PS= 1.

FILE 0. METHOD 0. RUN 339 INDEX 339

PEAK#	AREA%	RT	AREA	BC	
1	0.642	0.3	143948	01	
2	0.879	1.5	197104	01	
3	19.775	2.09	4432587	01	- sorbitol
4	43.078	3.74	9656142	02	- glucose
5	35.625	4.09	7985464	03	- fructose
TOTAL	100.		22415245		

CHANNEL A INJECT 03/20/98 10:26:08



03/20/98 10:26:08 CH= "A" PS= 1.

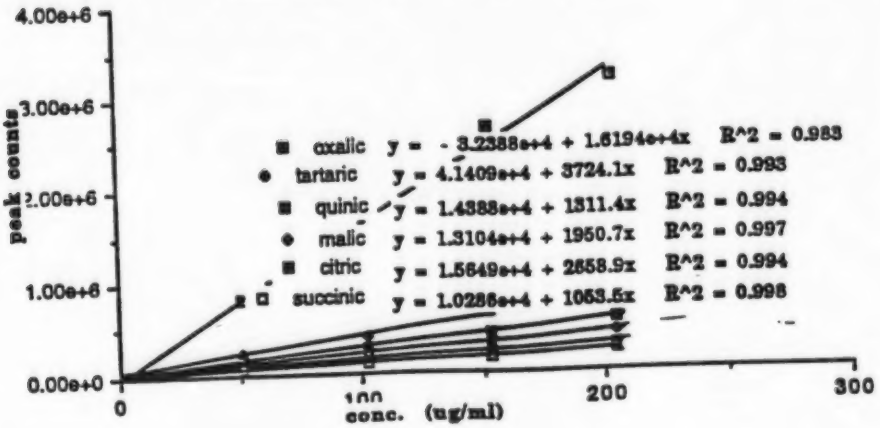
FILE 0. METHOD 0. RUN 340 INDEX 340

PEAK#	AREA%	RT	AREA	BC	
1	0.844	1.5	187047	01	
2	9.881	2.09	2190313	01	- sorbitol
3	43.371	3.73	9617020	02	- glucose
4	35.904	4.09	7961316	03	- fructose
TOTAL	100.		22173696		

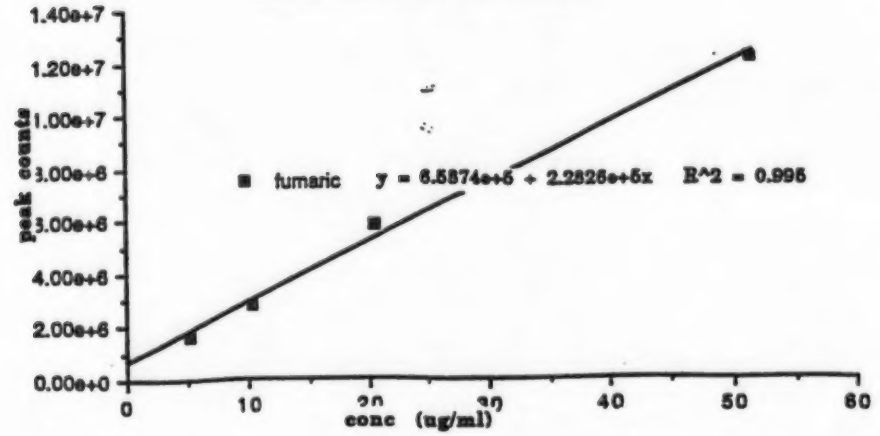
COOH stds

Column 1	conc.	oxalic	t	tartaric	q	quinic	m
Standards Feb. 24/98							
oxalic	51.100	810522.000	51.200	235227.000	50.100	83084.000	50.400
	102.200	1503557.000	102.400	402819.000	100.200	141630.000	100.800
	153.300	2641972.000	153.600	640138.000	150.300	223941.000	151.200
	204.400	3189377.000	204.800	790455.000	200.400	279021.000	201.600
citric	50.000	162461.000					
	100.000	268193.000					
	150.000	428811.000					malic
	200.000	561819.000					
succinic	50.200	86794.000					
	100.400	113845.000					
	150.600	172001.000					118594.000
	200.800	226860.000					201667.000
							316303.000
fumaric	5.140	1650593.000					412647.000
	10.280	2826198.000					
	20.560	5860039.000					
	51.400	12241687.000					

Mar. 5 Mixed COOH Standards

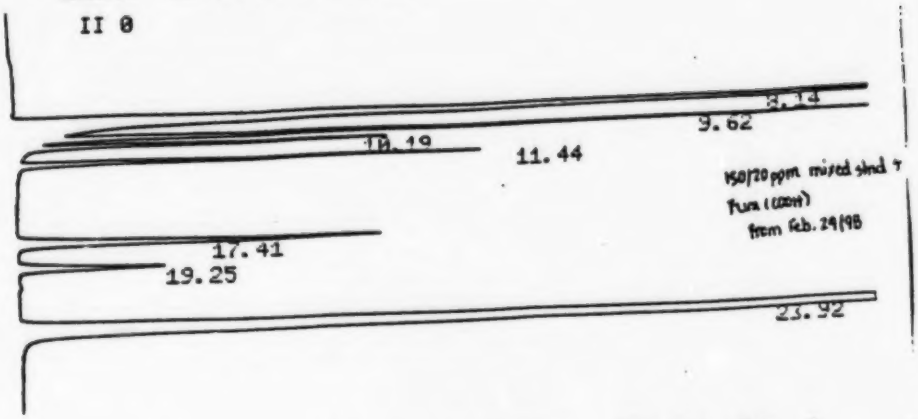


Mar.5 Mixed COOH Standard



CHANNEL A INJECT 03/05/98 10:18:25

II 0



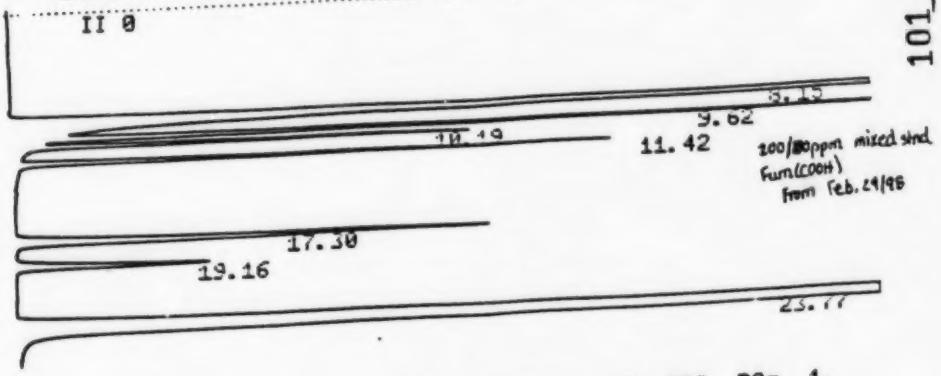
03/05/98 10:18:25 CH= "A" PS= 1.

FILE 1. METHOD 0. RUN 85 INDEX 85

PEAK#	AREA%	RT	AREA BC
1	25.692	8.14	2641972 01
2	6.225	9.62	640138 01
3	2.178	10.19	223941 01
4	3.076	11.44	316303 01
5	4.17	17.41	428811 01
6	1.673	19.25	172001 01
7	56.987	23.92	5860039 01
TOTAL	100.		10283205

CHANNEL A INJECT 03/05/98 10:48:52

II 0

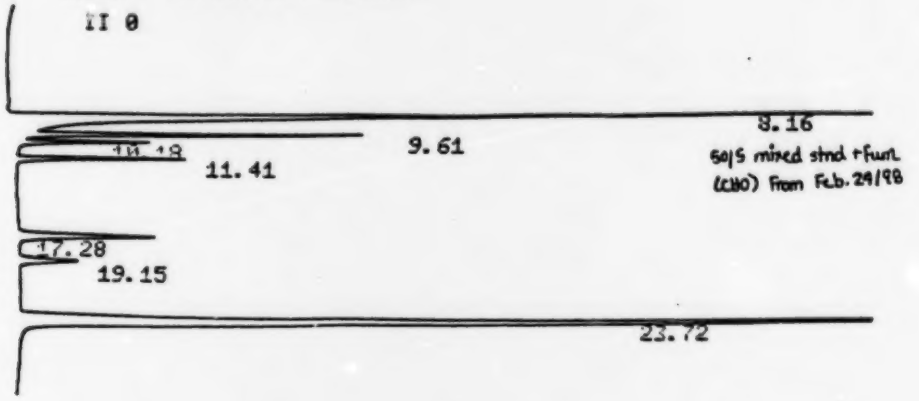


03/05/98 10:48:52 CH= "A" PS= 1.

FILE 1. METHOD 0. RUN 86 INDEX 86

PEAK#	AREA%	RT	AREA BC
1	18.017	8.15	3189377 01
2	4.465	9.62	790455 01
3	1.576	10.19	279021 01
4	2.331	11.42	412647 01
5	3.174	17.3	561819 01
6	1.282	19.16	226860 01
7	69.155	23.77	12241687 01
TOTAL	100.		17701866

CHANNEL A INJECT 03/05/98 09:19:41

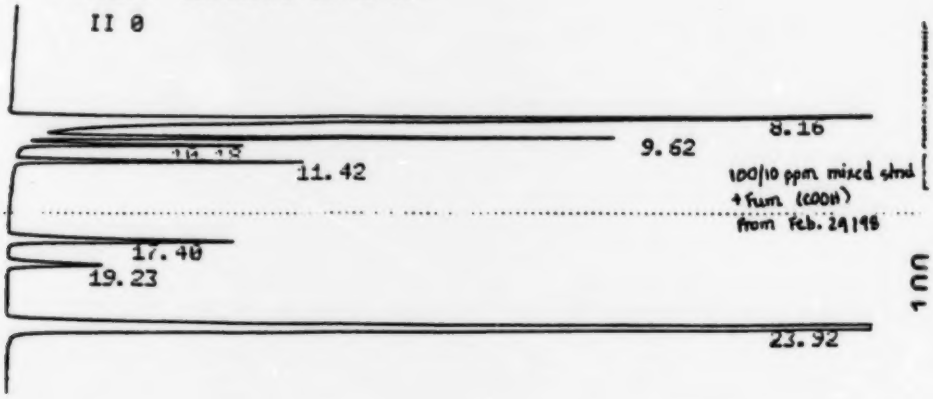


03/05/98 09:19:41 CH= "A" PS= 1.

FILE 1. METHOD 0. RUN 83 INDEX 83

PEAK#	AREA%	RT	AREA	BC
1	25.918	8.16	810522	01
2	7.522	9.61	235227	01
3	2.657	10.18	83084	01
4	3.792	11.41	118594	01
5	5.195	17.28	162461	01
6	2.136	19.15	66794	01
7	52.781	23.72	1650593	01
TOTAL	100.		3127275	

CHANNEL A INJECT 03/05/98 09:49:15

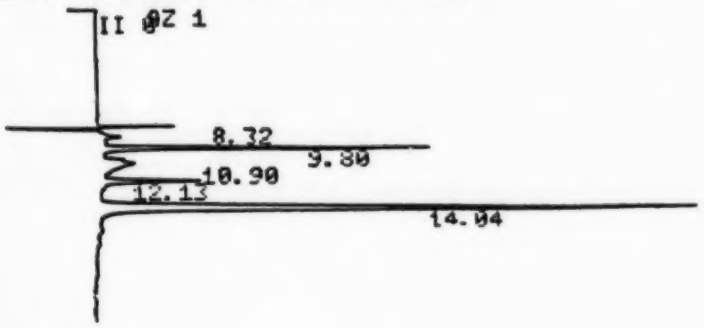


03/05/98 09:49:15 CH= "A" PS= 1.

FILE 1. METHOD 0. RUN 84 INDEX 84

PEAK#	AREA%	RT	AREA	BC
1	27.538	8.16	1503557	01
2	7.378	9.62	402819	01
3	2.594	10.18	141630	01
4	3.694	11.42	201667	01
5	4.912	17.4	268195	01
6	2.085	19.23	113845	01
7	51.799	23.92	2828198	01
TOTAL	100.		5459911	

CHANNEL A INJECT 04/08/98 10:02:27



a)

#1 06C97 DF=133.3

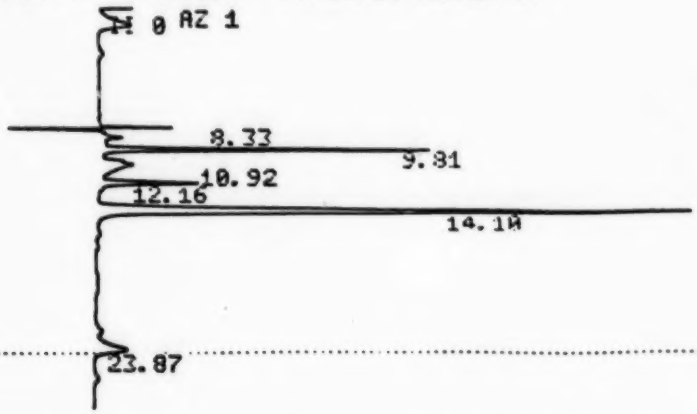
ORGANIC ACIDS 04/08/98 10:02:27 CH= "A" PS= 1.

FILE 1. METHOD 0. RUN 98 INDEX 98

ANALYST: CINDY

PEAK#	AREA%	RT	AREA	BC	
1	3.509	8.32	32768	01	
2	19.292	9.8	180131	01	-quinic
3	4.188	10.9	39100	01	-malic
4	7.434	12.13	69408	01	
5	65.577	14.04	612298	01	
TOTAL	100.		933705		

CHANNEL A INJECT 04/08/98 10:25:04



#1 06C97 DF=133.3

ITEM CHROMATOGRAPHIC

148

ORGANIC ACIDS 04/08/98 10:25:04 CH= "A" PS= 1.

FILE 1. METHOD 0. RUN 99 INDEX 99

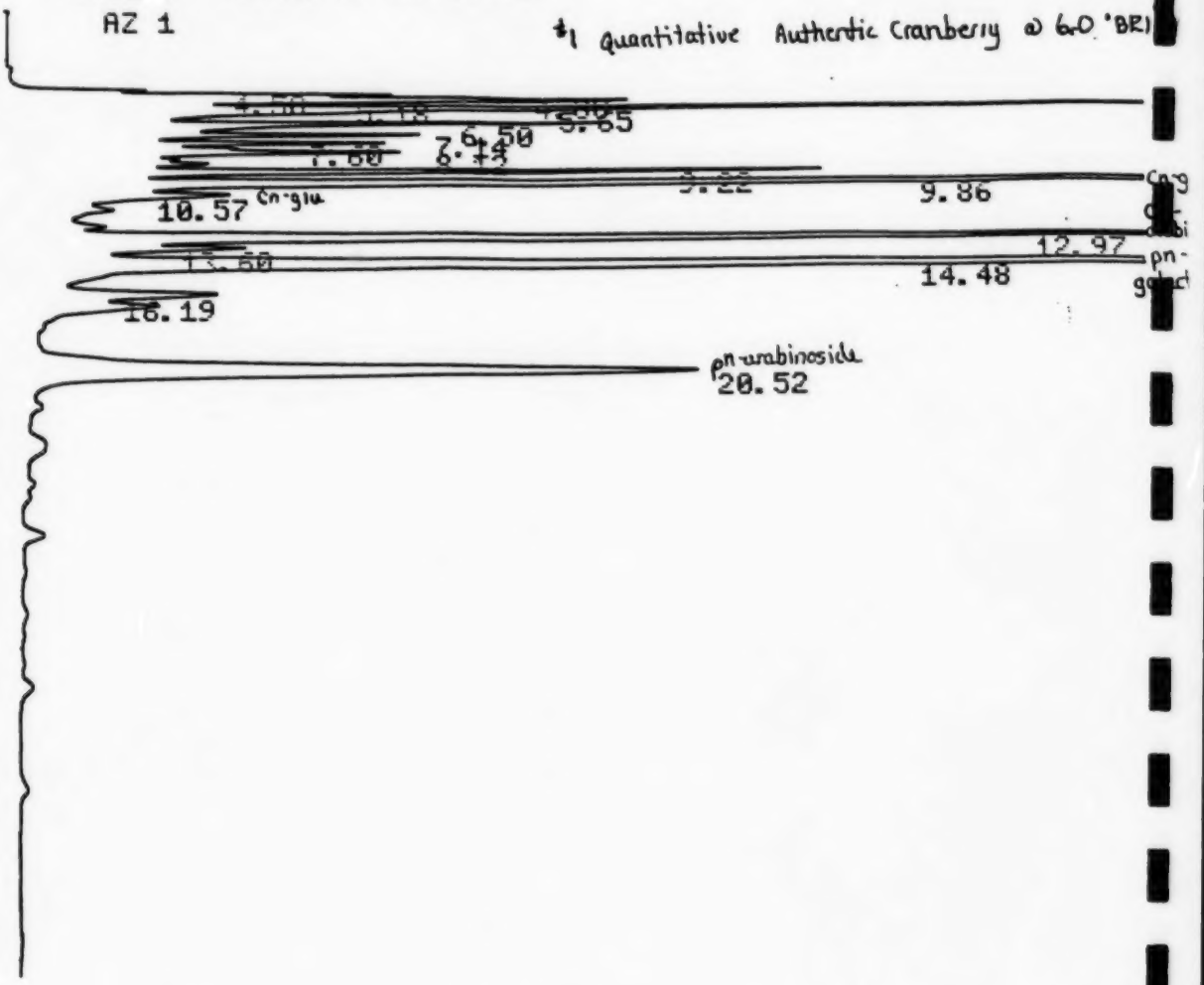
ANALYST: CINDY

PEAK#	AREA%	RT	AREA	BC	
1	3.212	8.33	30994	01	
2	18.33	9.81	176883	01	-quinic
3	4.088	10.92	39454	01	-malic
4	7.17	12.16	69188	01	
5	63.646	14.1	614196	01	
6	3.554	23.87	34301	01	
TOTAL	100.		965016		

CHANNEL A INJECT 01/26/99 08:55:48

AZ 1

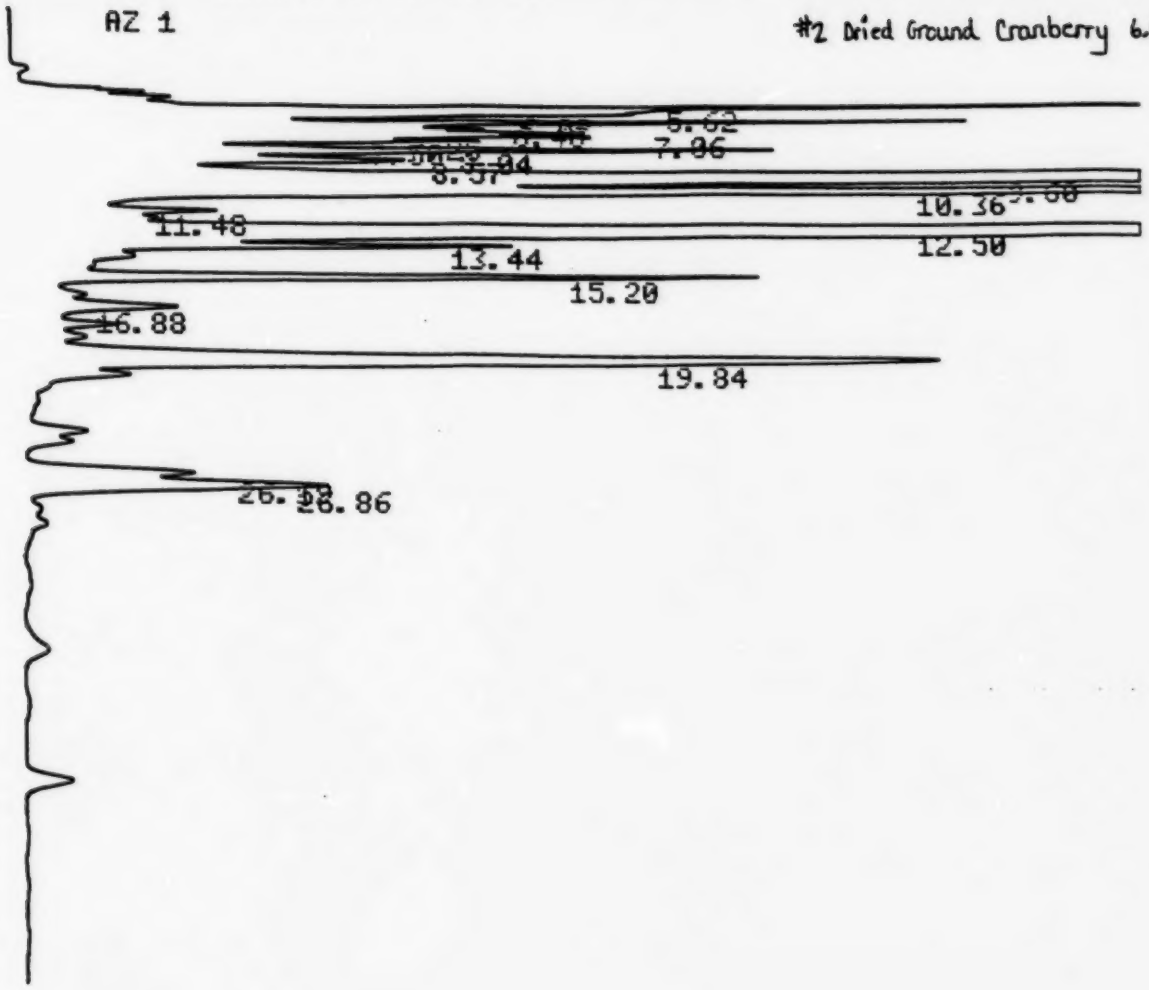
#1 Quantitative Authentic Cranberry @ 6.0 °BRI



01/26/99 08:55:48 CH= "A" PS= 1.

FILE 1. METHOD 0. RUN 45 INDEX 45

PEAK#	AREA%	RT	AREA	BC
1	0.689	4.58	234164	02
2	1.994	4.88	677925	02
3	5.387	5.18	1831552	02
4	9.152	5.65	3111602	03
5	2.063	6.5	701232	01
6	1.268	7.14	430946	01
7	0.937	7.6	318707	01
8	1.178	8.12	400345	01
9	4.689	9.22	1594057	02
10	16.562	9.86	5630949	03**
11	0.903	10.57	306993	01**
12	14.93	12.97	5075908	02
13	1.612	13.6	547948	02
14	21.878	14.48	7438147	03
15	3.928	16.19	1335441	01
16	12.832	20.52	4362895	01
TOTAL	100.		33998811	



12/16/98 09:31:04 CH= "A" PS= 1.

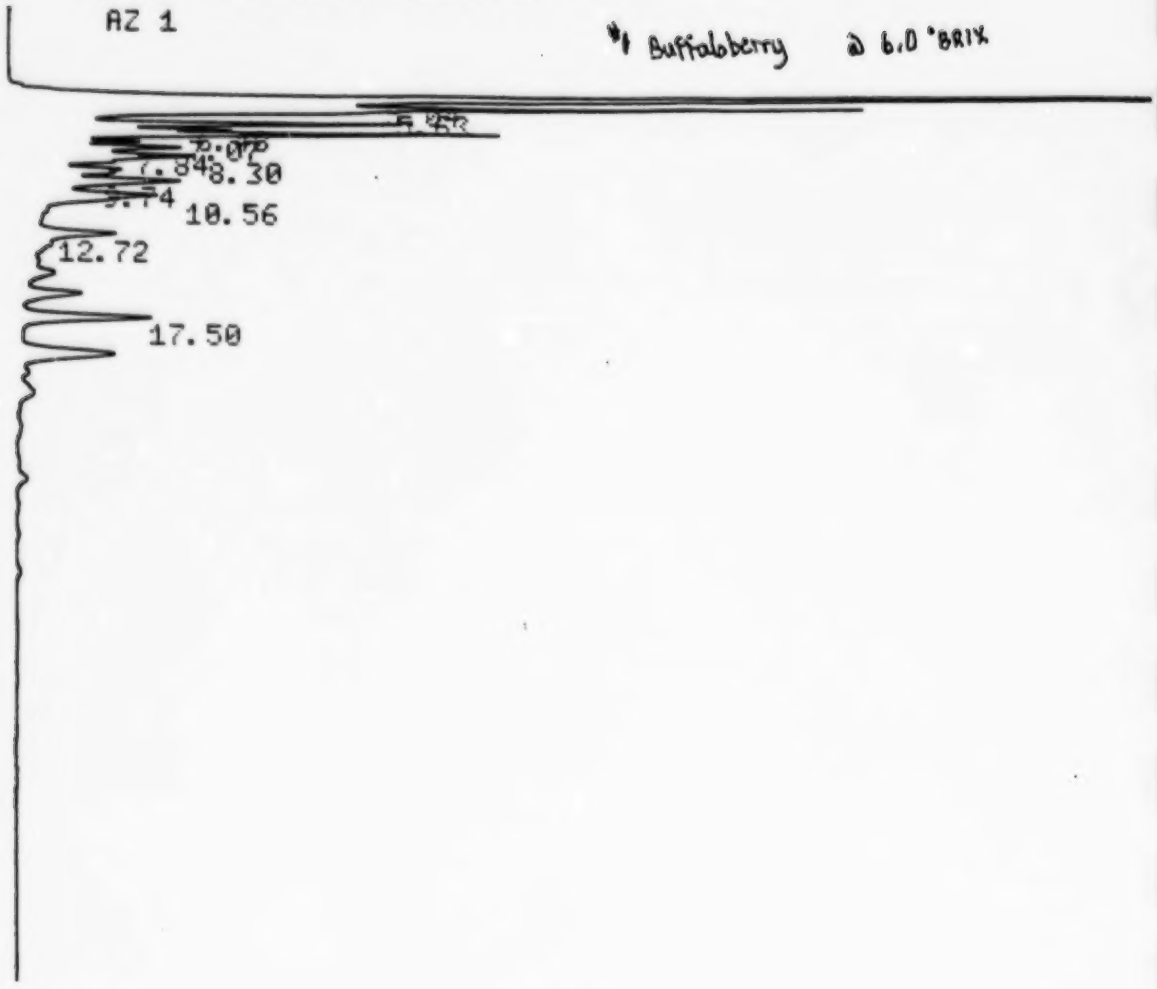
LE 1. METHOD 0. RUN 58 INDEX 58

EAK#	AREA%	RT	AREA	BC	
1	3.452	5.62	4661953	02	
2	1.272	6.02	1718569	02	
3	1.962	6.46	2649889	02	
4	1.469	7.06	1984211	02	
5	0.924	7.25	1248209	02	
6	0.714	7.5	963948	02	
7	1.925	8.04	2599401	02	
8	1.117	8.57	1509063	02	
9	39.514	9.6	53366029	02	→ Cn-gal
10	7.141	10.36	9643975	03	→ Cn-glu
11	0.165	11.48	222642	01	–
12	30.757	12.5	41539172	02	
13	0.839	13.44	1133265	03	
14	1.759	15.2	2375729	01	
15	0.382	16.88	516412	01	
16	4.412	19.84	5958477	01	
17	0.766	26.19	1034703	02	
18	1.429	26.86	1930454	03	
TAL	100.		135056101		

CHANNEL A INJECT 01/20/99 09:51:24

AZ 1

#1 Buffaloberry @ 6.0 °BRIX



01/20/99 09:51:24 CH= "A" PS= 1.

FILE 1. METHOD 0. RUN 17 INDEX 17

PEAK#	AREA%	RT	AREA	BC
1	35.714	5.04	5144219	02
2	19.148	5.63	2758057	02
3	6.61	6.48	952044	02
4	12.114	7.07	1744936	02
5	3.365	7.84	484738	02
6	5.821	8.3	838454	02
7	7.437	9.74	1071272	02
8	4.306	10.56	620208	03
9	1.709	12.72	246157	01
10	3.775	17.5	543697	01
TOTAL	100.		14403782	